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THE SHOCK AND VIBRATION DIGEST

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Code 5804, Naval Research Laboratory
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SVIC NOTES

The advance unclassified program for the 52nd Shock and Vibration Symposium is printed on other pages of this issue and I would like to briefly comment on the several special sessions that have been planned.

One of the special sessions concerns vibration problems in rotating machinery. This will contain a series of invited and contributed papers and its purpose will be to provide insight into the structural dynamics problems that are inherent in the design, analysis and operation of rotating machinery. The topics to be addressed include the sources of vibration, how they are measured and how their effects are controlled.

The first flight of the Space Shuttle, last April, resulted in the availability of many structural dynamic measurements. Some of these will be discussed in a series of invited papers in three special sessions on the Space Shuttle dynamics efforts.

The papers in the first of these sessions will concern the analytical and experimental loads and dynamics efforts; they will describe development and the verification of the many structural dynamics models as well as comparisons between predicted and measured flight loads.

The development of data systems and the environmental testing programs will be considered in the second special session on Space Shuttle dynamics. The papers to be presented will describe the development of data banks and automated data handling systems, the development and verification of environmental test criteria and test programs to certify the structural integrity of the total vehicle or its components.

The last session in this series will be devoted to the subjects of the Space Shuttle Thermal Protection System and the Space Shuttle Main Engine. These papers will describe the dynamic characteristics of the thermal protection system and the analytical and experimental programs that were undertaken to make it flightworthy. They will also describe the analytical and experimental programs that were undertaken to solve the dynamics problems in connection with the development of the Space Shuttle Main Engine.

Other sessions are planned which will include papers on structural dynamics, dynamic testing and vibration control. Many papers, in these and in the special sessions, are expected to reveal unique test or analysis methods or significant technological advances.

R.H.V.

EDITORS RATTLE SPACE

SHOCK AND VIBRATION SYMPOSIA

This issue of the DIGEST contains the program for the 52nd Shock and Vibration Symposium, which will be held in New Orleans from October 27 through 29. The program contains papers on a wide variety of subjects including the design and development of the space shuttle. Because so many types of hardware are involved in the papers that will be presented, the symposium will afford the vibration engineer an opportunity to learn about solutions to space shuttle related problems and perhaps adapt these solutions to problems in his own field. In addition, such new techniques as environmental screening will be reported at the meeting.

The Symposium is the oldest continuing meeting (since 1947) concerned with the specialized areas of shock and vibration. Over the years, much new technology has been presented at these meetings. Much of the work reported relates to practical problems the solutions of which require knowledge of the fundamentals of physics and scientifically-oriented techniques. Several years ago the scope of the Symposium was broadened to include survey, historical, and philosophical material in Plenary lectures. The Elias Klein memorial lecture (Klein established the Shock and Vibration Information Center) provides a rare opportunity for a speaker to interpret the consequences of new technology.

Although the Symposium was originally conceived as a mechanism for the exchange of information among the armed forces, it now also provides a forum for engineers in industry and universities in both the U.S.A. and many foreign countries. I can assure you that your participation in the Symposium will contribute to an awareness of the latest shock and vibration technology, its implementation, and the technological challenges remaining.

R.L.E.

LINEAR DYNAMIC THERMOELASTICITY - A SURVEY

J. Ignaczak*

Abstract. This survey presents a historical development of linear dynamic thermoelasticity over the last 30 years. A linear theory of non-steady heat conduction is combined with elastodynamics to describe thermo-mechanical processes in a solid body. Because of the complicated structure of the governing equations, only a few one-dimensional initial-boundary value problems have thus far been solved in a form that allows their complete analysis. A relatively large number of problems that have been solved successfully concern periodic thermoelastic disturbances. The reason is that the periodicity hypothesis allows the reduction of the governing equations to classical Helmholtz equations with complex-valued wave numbers and to application of the methods of classical elastodynamics to solution of actual problems. The survey also includes descriptions of fundamental results and of a basic system of field equations for dynamic thermoelasticity with relaxation times. Suggestions concerning areas of the theory that are critically in need of further investigations are given.

Relatively few articles and monographs on dynamic thermoelasticity have been published thus far. Dynamic thermoelasticity combines the classical theory of non-steady heat conduction and classical elastodynamics in the sense that mechanical disturbances propagating in a solid body produce variations of its temperature and vice versa (a change of temperature results in a deformation process of the body). For a linear homogeneous isotropic thermoelastic body the mutual interaction between the temperature and deformation fields is conditioned by the presence in the governing equations of a positive parameter $\underset{\sim}{\epsilon}$ which couples the mechanical and temperature effects. In the case of $\underset{\sim}{\epsilon} = 0$ dynamic thermoelasticity leads to classical heat conduction theory and a dynamic theory of thermal stresses. The last theory is reducible to classical elastodynamics.

The literature devoted to coupled dynamic thermoelasticity began long before World War II [1-5]. Interest in this field was revived after the War as a result of development of new technologies in the aircraft industry, nuclear engineering, and shipbuilding. Basic initial-boundary value problems of dynamic thermoelasticity are difficult to solve; in addition, $\underset{\sim}{\epsilon}$ is a small parameter. As a result, many of the articles and monographs on thermoelasticity published during the last 30 years are devoted to uncoupled thermoelasticity ($\underset{\sim}{\epsilon} = 0$) or to approximate and numerical solutions of the coupled theory. Important monographs in which up-to-date material on thermoelasticity is compiled are available [6-19]. These monographs also include lists of references to original works.

One of the earliest papers in which an initial-boundary value problem of dynamic thermoelasticity with $\underset{\sim}{\epsilon} = 0$ was solved is by Danilovskaya [20]. The problem concerned an elastic semi-space suddenly heated on its stress-free boundary. Because external heating was applied uniformly to the entire boundary, the problem was one dimensional in space; both temperature and the corresponding thermal stresses inside the semi-space were obtained in a closed form. Such a form allowed detailed analysis of the solution concerned. This one-dimensional solution revealed an important property of a general solution in uncoupled dynamic thermoelasticity: a non-steady thermal stress is the sum of two fields -- a heat-like field that propagates with infinite speed throughout a solid and a wave-like field that propagates with finite speed. During the last 30 years the Danilovskaya problem has been modified in a variety of ways [21-27]. A general solution to the coupled Danilovskaya problem has been obtained as the sum of two real integrals -- an infinite integral and a discontinuous finite integral [24] -- as well as an alternative series form of solution [27]. The Danilovskaya problem is included in basic monographs on thermoelasticity [7, 10, 13, 15, 18].

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The one-dimensional spherical problem should be mentioned: the propagation of thermal stresses produced by an instantaneous concentrated source of heat in an infinite elastic space [28]. Another problem involves a thermal shock in an elastic body with a spherical cavity [29]. Both problems were solved in a closed form leading to a detailed analysis only for the case $\tilde{\epsilon} = 0$. A generalization of results [28] to include coupling effects has been proposed [30].

Another class of dynamic thermoelastic problems concerns thermoelastic disturbances that are periodic in time. The periodicity hypothesis allows the governing equations to be reduced to classical Helmholtz equations with complex-valued wave numbers and the application of the methods of classical elastodynamics to solution of actual thermoelastic problems [31]. Use of the hypothesis has resulted in the large number of papers on dynamic thermoelasticity that have been published to date.

The following periodic problems are the most interesting:

- Plane harmonic waves in an infinite thermoelastic space, a semi-infinite thermoelastic space, and a thermoelastic layer
- Spherical and cylindrical waves in an infinite thermoelastic space
- Rayleigh and Lamb waves in a thermoelastic semi-space
- Diffraction of thermoelastic waves by a spherical cavity or a cylindrical hole in an infinite space [15]

For each problem a pair of complex-valued wave numbers, associated with a central equation of the coupled theory, generates a pair of phase velocities and a pair of damping coefficients that are the basic characteristics of a periodic thermoelastic wave.

A mathematical theory of a thermoelastic body vibrating periodically in time -- i.e., existence and uniqueness theorems – an analysis of differential properties of solutions, and a method for constructing solutions using generalized Fourier series based on a theory of singular integral equations have been published [17, 32].

THERMOELASTICITY WITH FINITE WAVE SPEEDS

Classical coupled thermoelasticity is described by hyperbolic-parabolic equations that imply an infinite speed of thermoelastic disturbances in a solid. Because such an implication is not acceptable from a physical point of view, new thermoelastic theories aimed at eliminating the infinite speed paradox have appeared in the technical literature. Two of these theories are discussed in this section. For a homogeneous isotropic linear thermoelastic solid both theories can be described by the following system of field equations.

The strain-displacement relation

$$\underline{E} = \tfrac{1}{2}\,(\underline{\nabla}\underline{u} + \underline{\nabla}\underline{u}^T) \tag{1}$$

The equation of motion

$$\mathrm{div}\,\underline{S} + \underline{b} = \tilde{\rho}\,\ddot{\underline{u}} \tag{2}$$

The energy equation

$$-\,\mathrm{div}\,\underline{q} + r = \hat{\tilde{c}}_E\dot{\tilde{\theta}} + (3\tilde{\lambda} + 2\tilde{\mu})\,\tilde{\alpha}\tilde{\theta}_0\mathrm{tr}\dot{\underline{E}} \tag{3}$$

The stress-strain-temperature relation

$$\underline{S} = 2\tilde{\mu}\underline{E} + \tilde{\lambda}(\mathrm{tr}\underline{E})\underline{1} - (3\tilde{\lambda} + 2\tilde{\mu})\hat{\tilde{\alpha}}\tilde{\theta}\,\underline{1} \tag{4}$$

The head conduction equation

$$\underline{q} = -\hat{k}\underline{\nabla}\tilde{\theta} \tag{5}$$

The operators $\hat{c}_E$, $\hat{\tilde{\alpha}}$, and $\hat{k}$ in equations (3), (4), and (5) respectively are defined by

$$\hat{c}_E = c_E(1 + t_0\partial/\partial t) \tag{6}$$

$$\hat{\tilde{\alpha}} = \tilde{\alpha}(1 + t_1\,\partial/\partial t) \tag{7}$$

$$\hat{k} = k(1 + t^*\partial/\partial t)^{-1} \tag{8}$$

The superimposed dot indicates differentiation with respect to time t; e.g., $\dot{\underline{u}} = \partial\underline{u}/\partial t$. Moreover, the functions $\underline{u}$, $\underline{E}$, $\underline{S}$, $\tilde{\theta}$, $\underline{q}$, $\underline{b}$, and r are the displacement, strain, stress, temperature difference, heat flux, body force, and heat supply fields respectively. The functions $\tilde{\rho}$, $\tilde{\lambda}$ and $\tilde{\mu}$, $\tilde{\alpha}$, k, and c_E are the density, the Lamè moduli, the coefficient of thermal expansion,

the conductivity, and the specific heat for zero deformation respectively. The function $\underset{\sim}{\theta}_0$ in equation (3) is a fixed reference temperature ($\underset{\sim}{\theta}_0 > 0$); $\underline{1}$ in equation (4) represents a unit tensor. Finally $\bar{t}_0$, t_1, and t^* in equations (6), (7), and (8) are the relaxation times.

The material constants and the relaxation times obey the inequalities

$$\underset{\sim}{\rho} > 0, k > 0, C_E > 0, \underset{\sim}{\alpha} > 0 \tag{9}$$

$$\underset{\sim}{\mu} > 0, 3\underset{\sim}{\lambda} + 2\underset{\sim}{\mu} > 0 \tag{10}$$

$$t_1 \geqslant t_0 \geqslant 0, t^* \geqslant 0 \tag{11}$$

If $t_0 = t_1 = 0$ and $t^* > 0$, equations (1) through (11) reduce to the basic field equations of a generalized dynamic thermoelasticity, called the L-S theory and proposed by Lord and Shulman [33]. If $t_1 \geqslant t_0 > 0$ and $t^* = 0$, equations (1) through (11) represent a dynamic thermoelasticity, called the G-L theory and developed by Green and Lindsay in [34]. Finally, if $t_0 = t_1 = t^* = 0$, equations (1) through (11) reduce to the basic field equations of a classical coupled thermoelasticity [16]. Thus the results surveyed in the first section of this review are described by equations (1) through (11) with $t_0 = t_1 = t^* = 0$.

One-dimensional problems of generalized dynamic thermoelasticity concern plane harmonic waves and thermal shock on a semi-space or a spherical cavity in an infinite space and have been discussed [33, 35-39]. A survey on thermo-mechanical effects in elastic wave propagation, governed by equations (1) through (11) with $t_0 = t_1 = 0$ and $t^* > 0$ is available [40].

One result of the generalized thermoelasticity obtained recently is a domain of influence theorem [41, 46]. This theorem asserts that, for a finite time $t > 0$, a solution $[\underline{u}, \underline{E}, \underline{S}, \underset{\sim}{\theta}, \underline{q}]$ that satisfies equations (1) through $\overline{(11)}$ on $\bar{B}x\overline{(0, \infty)}$ -- B = domain occupied by a body and $(0, \infty)$ = time interval -- and complies with suitable initial and boundary data of a bounded support vanishes outside a bounded domain D_t. The function D_t is called the domain of influence of the data at time t associated with the problem; D_t is defined in terms of support of the data, material constants, and relaxation times. Therefore, the theorem implies that thermoelastic disturbances obeying equations (1) through (11) propagate only with a finite speed; for this reason a theory described by equations (1) through (11) with non-vanishing relaxation times can be called a thermoelasticity with finite wave speeds.

Another characteristic result of generalized dynamic thermoelasticity is contained in a decomposition theorem [42, 47]. This theorem is similar to a Boggio result in linear elastodynamics [48] and shows that a thermoelastic disturbance can be split into two fields, each of which propagates with a different finite velocity. The decomposition theorem plays an important role in the solution of actual problems of generalized dynamic thermoelasticity, or GDT [49].

Among other general results obtained in GDT the following deserve attention: a natural formulation [43, 45] of GDT in terms of a pair $(\underline{S}, \underset{\sim}{\theta})$ or $(\underline{S}, \underline{q})$ and a variational characterization of $\overline{\text{GDT}}$ in terms of a pair $(\underline{S}, \underline{q})$. The variational description can be used to solve a number of problems of GDT without resorting to equations (1) through (11).

CLOSURE

Linear dynamic thermoelasticity is now a well formulated theory of solid mechanics. It is also a well developed discipline under the assumption of zero relaxation times. However, dynamic thermoelasticity is not yet as mature as classical linear elastodynamics [31] or the theory of non-steady heat conduction in a solid [50]. To date no effective Green function corresponding to an instantaneous concentrated source of heat in an infinite thermoelastic space has been obtained. In an exception [30] such a function for zero relaxation times is constructed in a complicated series form. An effective singular solution of dynamic thermoelasticity corresponding to an instantaneous concentrated mechanical force acting in an infinite space has not been found. The shortage of basic singular solutions implies a shortage of integral representation theorems of the Love type and a deficit in integral equation formulation of the initial-boundary value problems of dynamic thermoelasticity. The integral representations and formulations of classical elastodynamics are available [31]. An attempt should also be made to find the exact solutions to actual initial-boundary value problems

in one-, two-, and three-dimensional thermoelastic solids.

It appears that the search for solutions to the above problems should be preceded by an analysis of basic properties of wave equations with convolutions that occur in the decomposition theorem for a central equation of dynamic thermoelasticity [42].

Moreover, the dynamic thermoelasticity described by equations (1) through (11) is in need of experimental verification. For the L-S theory – i.e., for $t_0 = t_1 = 0$ and $t^* > 0$ -- Francis [40] proposed a number of materials for which the relaxation time t^* can be estimated. For example, $t^* = 6.6 \times 10^{-14}$ sec for uranium dioxide at 25°C, and $t^* = 1.6 \times 10^{-12}$ sec for carbon alloys at 25°C. For the G-L theory, in which $t_0 \geqslant t_1 > 0$ and $t^* = 0$, the existence of the relaxation times t_0 and t_1 should be proved experimentally, at least for some materials.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles inlcude technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about plate vibration research and parametric vibration.

Dr. A.W. Leissa of Ohio State University, Columbus, Ohio has written a two-part paper summarizing recent research in free, transverse vibrations of plates. The present paper deals with problems governed by the classical theory of plates; i.e , homogeneous, isotropic, thin, constant thickness, no inplane initial forces, small transverse displacements, vibrating in a vacuum, etc.

Dr. R.A. Ibrahim of Texas Tech University, Lubbock, Texas, has written an article reviewing recent developments and results of the theory of random parametric vibration that have been published since 1976.

PLATE VIBRATION RESEARCH, 1976 - 1980: CLASSICAL THEORY

A.W. Leissa*

Abstract. This paper is the first of two summarizing recent research in free, transverse vibrations of plates. The present paper deals with problems governed by the classical theory of plates; i.e., homogeneous, isotropic, thin, constant thickness, no inplane initial forces, small transverse displacements, vibrating in a vacuum, etc.

INTRODUCTION

This paper surveys the literature of free vibrations of plates which has appeared during the period 1976 - 1980. It is a continuation of the previous review [1] which covered the period 1973 - 1976.

As in the previous surveys [1, 2] the present work is divided into two parts and follows the outline of the writer's earlier monograph [3]; that is, this paper deals with vibrations of plates according to classical theory and it will be followed by one which deals with complicating effects. All of these review papers serve to supplement the original monograph [3] which, with passing years, is rapidly becoming out of date. The monograph provided a reasonably complete summary of the plate vibration literature through the year 1965. The period 1966 - 1972 is partially summarized by a reference list which the writer prepared for a set of short course notes [4], and which is available upon request.

Classical theory of plate vibrations can be regarded as that body of knowledge governed by the well known equation of motion

$$D\nabla^4 w + \rho \frac{\partial^2 w}{\partial t^2} = 0 \tag{1}$$

along with appropriate boundary conditions. That is, the plate is assumed to be thin, of uniform thickness, and to be made of a material which is homogeneous, isotropic and linearly elastic. The transverse vibrational displacement (w) is small compared with the thickness and no significant forces may act ***in the plane*** of the plate, either due to initial stresses or due to displacements. Of course, transverse shearing forces and bending moments due to vibration displacements are present in the classical theory. Finally, the plate is assumed to vibrate in a vacuum. If any of these assumptions is significantly violated, the resulting problem falls outside the scope of the present paper, but within that of the subsequent paper to appear.

In both papers only transverse (i.e., flexural) vibrations will be considered. Inplane (i.e., stretching) vibrations occur at much greater frequencies for thin plates. Only simple plates will be considered, not structures consisting of plates stiffened by other structural members (e.g., rods, beams, plates, shells). For this reason plates of stepped thickness will be omitted from consideration. On the other hand, plates having elastic supports either along the boundary or in their interior will be included, provided the mass of the support can be neglected. Finally, in both papers neither forced response nor damped motion will be treated.

References in the present work were obtained from careful searches of The Shock and Vibration Digest, Applied Mechanics Reviews and Scientific and Technical Aerospace Reports, supplemented by a number which were sent by their authors to the present writer. Thus the writer is reasonably certain that most of the significant references dealing with plate vibrations which have been published during the period 1976 - 1980 are included in this and the forthcoming paper.

Several other survey papers interfacing with the subject of plate vibrations have appeared in this

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journal in recent years. These include ones by Elishakoff [5], Reddy [6] and Bert [7]. The last is one of a series of excellent surveys in the important area of fibrous composite materials which have been compiled by Professor Bert during the past decade.

CIRCULAR PLATES

Although analytical solutions for circular plate vibration problems have been available for as long as 150 years, there is still work to be done in providing complete and accurate numerical results.

A particularly notable contribution was recently made by Itao and Crandall [8] who published the lowest 701 frequencies and corresponding modal coefficients (amplitude ratios) for the thin, circular plate having free edges and Poisson's ratio (ν) of 0.330. Numerical results were given with six significant figure accuracy. The study was necessitated by the need for modal information for an investigation of a wide-band random vibration problem.

A comprehensive set of results for the simply supported plate was presented by Leissa and Narita [9]. Nondimensional frequency parameters having six significant figures were tabulated for all values of $n + s \leqslant 10$, where n and s are the numbers of nodal diameters and internal nodal circles, respectively, and for $\nu = 0, 0.1, \ldots 0.5$. Simplified formulas for determining additional values of frequencies for large s were also derived by the use of asymptotic expansions.

Other studies on classical circular plate vibration problems were recently conducted by Zeytinci [10] and by Takeyama [11]. Asano [12] showed how an iterative procedure can be applied with the Rayleigh method to obtain rapidly converging results for circular plate frequencies. Hirano and Okazaki [13] used a weighted residual method to obtain numerical results for three types of intermittent boundary conditions; viz, clamped-simply supported, clamped-free and simply supported-free. Sundararajan [14] also treated the clamped-simply supported case.

Elastically supported circular plates have received considerable attention in the recent literature [10, 15-21]. Particularly interesting was the work of Irie and Yamada [18] who analyzed circular plates having free boundaries, but which were supported intermittently along an internal circle which is concentric with the boundary. The internal circle arc supports provided translational and/or rotational elastic constraint. Frequencies and mode shapes were given for two and four circle arc supports located midway to the outer radius. They also dealt with the problem of the free circular plate supported elastically at interior points and presented some interesting mode shapes for plates simply supported or clamped at a single interior or boundary point, as well as those supported at three, equally-spaced interior or boundary points [19].

Leissa, Laura and Gutierrez [20] took up the case of circular plates having nonuniform elastic edge constraints; that is where the translational and rotational edge springs can vary continuously with θ (the circumferential coordinate). The problem was treated by expanding the variable spring coefficients into Fourier series. A numerical example was given for the case of a simply supported edge with rotational stiffness varying according to $L_0 + L_1 \cos\theta$. An alternative solution by means of the Ritz method was also presented. Narita and Leissa [21] extended the Fourier approach described above to deal with simply supported circular plates having intermittent, rotational springs distributed along the boundary. Extensive numerical results were given for plates having one, two or three equally spaced springs, and having various angles of constraint and magnitudes of spring constraint.

The effects of added mass were also considered, including a centrally located point mass [15] and intermittent, distributed boundary mass [22]. The former problem was solved by the Ritz method and the latter one by the Fourier expansion method described above [21].

Some further work has also taken place with ***annular*** plates of circular shape. Pardoen [23] obtained exact results for the annular plate having its outer boundary clamped and the inner free. Avalos and Laura [24] examined the effects of elastic edge constraints. Ramaiah and Vijayakumar [25] showed that annular plates having nearly equal radii behave like long, rectangular plates of the same width. Ginesu, Picasso and Priolo [26] obtained results for isotropic annular plates from analytical (finite element) and experimental (holographic) methods. Bucco, Mazumdar

and Sved [27] demonstrated the finite strip method on annular plates having the outer boundary clamped or simply supported and the inner boundary free.

Circular plates having an ***eccentric,*** circular inner boundary have also received attention [28-31], especially when the outer boundary is clamped and the inner boundary is a hole.

Finite element methods of various types are increasingly applied to circular plate vibration problems [6, 23, 26, 29, 32]. Holographic methods are also becoming more widely used in experimental investigations [26, 33, 34].

ELLIPTICAL PLATES

Although plates of elliptical shape have very little practical application, they do provide useful problems for the demonstration of analytical procedures intended for more general shapes. Clamped elliptical plates were analyzed by most of the recent authors [14, 28, 35-37] using various types of approximate methods. Solutions by Nayfeh et al [35] and, subsequently, by Eastep and Hemmig [28] used perturbation procedures based upon circular plate solutions. Additional numerical results were also obtained for the simply supported case [14, 37]. Sato [38] studied the case of the simply supported ellipse restrained by a uniformly distributed rotational spring along the boundary. The rather complicated solution of the equation of motion in elliptical coordinates (cf., [3], pp 2-3) was utilized to analyze the doubly symmetric modes.

RECTANGULAR PLATES

As it has been pointed out before [1, 39] there exist 21 distinct combinations of classical, uniform boundary conditions for rectangular plates. These combinations involve boundaries which are either clamped, simply supported or free. The fourth simple boundary condition involving zero slope and zero shear is difficult to realize in practice and is therefore generally ignored. These conditions do exist, however, along straight ***antinodal*** lines (i.e., lines of maximum displacement which occur in symmetrical mode shapes).

Six of the 21 cases have exact solutions; that is, the equation of motion and boundary conditions are exactly satisfied, with eigenvalue determinants of only ***finite*** size being required. These solutions arise when two opposite sides are simply supported. Indeed, in these cases the necessary determinants are no larger than ***fourth order.*** The remaining 15 cases require using one of a large number of possible approximate methods. Numerical r ults are then typically found by successive truncations of determinants of ***infinite order.*** If the approximate method is valid, then convergence to the exact values may be obtained to any desired degree of accuracy, provided the analyst is willing to pay the price of evaluating determinants which are typically of large order.

A typical rectangular plate of dimensions a x b is depicted in Figure 1. To provide conciseness and clarity in the discussion which follows, the same notation for identifying edge conditions will be adopted that the writer has used previously [1]; that is, beginning with the edge x = 0 and going counterclockwise around the plate, the symbols C, S and F will identify edges which are clamped, simply supported and free, respectively. Thus, the plate in Figure 1 is SCSF.

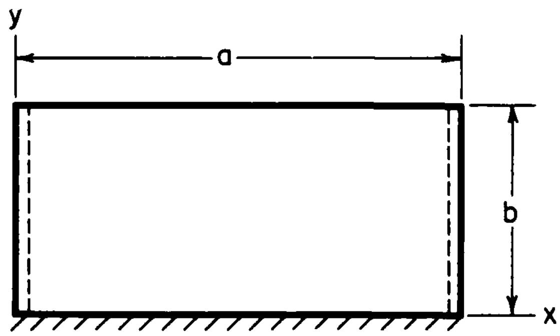

Figure 1. SCSF Rectangular Plate

Two Opposite Sides Simply Supported

All six cases of rectangular plates having two opposite sides simply supported have been thoroughly investigated by Gorman [40]. Characteristic determinants for all cases (except SSSS, where the frequency is available in a simple, closed form) were programmed for digital computer solution and extensive numerical results were presented. For the two cases where the

nondimensional frequency parameter $\lambda \equiv \omega a^2\sqrt{\rho/D}$ ($\omega\sim$ radial frequency, $\rho\sim$ mass/unit area, $D\sim$ flexural rigidity) does not depend upon ν (i.e., SCSC and SCSS) 64 values of λ are given to four significant figures for each of a large number of aspect ratios (a/b = 1/3, 0.4, 0.5, 2/3, 0.8, 1, 1.25, 1.5, 2, 2.5, and 3). The results agree with those of [39], where six significant figures were published. For those cases having one or more edges free (i.e., SCSF, SSSF, SFSF), λ depends upon ν, and the corresponding results were presented for two values of ν, (0.333 and 0.5). No accurate comparison with [39] is possible here, for ν = 0.3 was used in the earlier work.

Several other authors have recently studied plates having two opposite sides simply supported [14, 36, 41-43] using various methods, including approximate ones. Siewert and Phelps [43] used the theory of complex variables to develop exact, ***closed-form*** solutions of the transcendental equation

$$a \tan \bar{\xi} + \tanh \bar{\xi} = 0 \qquad (1)$$

which contains the characteristic equations for SCSC and SCSS as special cases.

Other Simple Edge Conditions

For the remaining 15 cases of plates having simple boundary conditions, the completely clamped (CCCC), cantilever (CFFF) and completely free (FFFF) cases have traditionally received by far the greatest attention of researchers [1, 3, 4]. This has remained the situation during the past four years.

A number of people have dealt with the CCCC plate [14, 27, 35, 36, 44-49], using various approximate methods and finding results of varying accuracy. Marangoni, Cook and Basavanhally [45] obtained reasonably accurate upper and lower bounds for the first two modes of the square plate. Vijakumar and Ramaiah [49] got results for the first nine modes from three methods and compared them with previously published accurate upper and lower bounds. A still better comparison of the various accurate results for the square was made by Narita [46], who used a series-type method to find the first 12 modes, and compared them with those of 13 others.

Reddy and Tsay [48], Gorman [50], Sankar and Hoa [51] and Klein [52] analyzed CFFF plates using finite elements, the superposition method, transfer functions and a Ritz method with Lagrange multipliers, respectively. The last approach [52] is particularly useful because, by the use of Lagrange multipliers together with a usual Ritz formulation of the problem, it yields ***lower*** bounds to complement the upper bounds attained by the oft used Ritz method. MacBain [53] used a cantilever plate to demonstrate an experimental procedure using time average holographic interferometry to determine frequencies, mode shapes and bending strain patterns at resonance.

The completely free plate was studied both analytically [54] and experimentally [55]. Other combinations of simple edge conditions receiving consideration in the recent literature included: CCCS [44], CCSS [41, 44] and CSSF [41].

More Complicated Support Conditions

Considerable attention has been devoted in recent years to plates supported in ways ***other than*** the simple, continuous edge conditions of clamped, simply supported and free. These other types of supports include: elastic supports (along the edges or internally), discontinuous edge supports, internal line supports and point supports (external or internal).

Laura and his colleagues [56-60] have analyzed a number of rectangular plate vibration problems involving elastically supported boundaries. Solutions were typically obtained by using Ritz-Galerkin methods and algebraic polynomial trial functions. Several other researchers [61-64] have also dealt with elastically supported rectangular plates. Leissa, Laura and Gutierrez [65-66] opened up a new class of problems for plates having ***nonuniform*** elastic supports (i.e., translational and/or rotational springs having stiffnesses which vary along the edges), thereby providing for more realistic representation of external structural support. Solutions were obtained by two methods, one using exact solutions of the equation of motion when two opposite edges are simply supported, and the other one using the Ritz method with algebraic polynomials.

Unlike previous years, little recent research has taken place on the vibrations of plates having discontinuous edge supports. The one exception is the work of Ogg [67] which took up the cantilever plate which

is clamped along only part of one edge, the remaining part being free. The free boundary thus represents a crack in the root (x = 0) of the cantilever plate. Numerical results were obtained for the first eight modes of plates having an aspect ratio (a/b in Figure 1) of two, and crack lengths varying from 0 to 0.7b. Analytical results were obtained from Ritz-Galerkin type of method and from a finite element model, and were compared with experimental ones.

On the other hand, considerable work has taken place on plates having internal line supports. Irie, Yamada and Narita [68] obtained sets of frequencies and mode shapes for the interesting problems of square plates having cross-shaped and square internal supports (Figure 2). For the first case the outer boundary was simply supported whereas points along the internal cross were either simply supported or clamped. In the second case both the external and internal supports were clamped. The second case was also investigated by Kurpa [69]. He also obtained results for rectangular plates clamped along an interior circular boundary, for both concentric and eccentric circles. Nagaya [70] also analyzed the rectangular plate having an eccentric circular inner boundary, with various combinations of outer and inner boundary conditions. Two other papers [52, 71] dealt with rectangular plates having additional interior line supports. Gorman [72, 73] studied rectangular plates supported along an entire diagonal. Takahashi and Chishaki [74] considered the rectangular plate attached to continuous supports going across the plate obliquely.

Apparently the only recent work on point-supported plates is that of Kersten [75, 76].

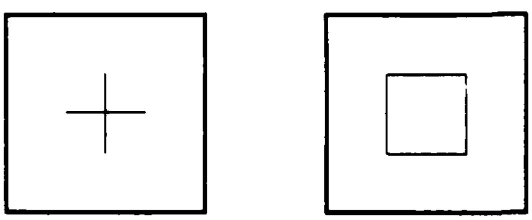

Figure 2. Square Plates having (a) Cross-Shaped and (b) Square Internal Supports

Added Mass

To the writer's surprise little could be found in the recent literature dealing with the effects of added mass. Whaley [77] made some comparisons between numerical results from an approximate analysis and experiment for a cantilever (CFFF) plate having an added, lumped mass.

Internal Cutouts and Cracks

Eastep and Hemig [28] treated the problem of a clamped square plate having a circular hole. Hirano and Okazaki [78] used a series form of solution for analyzing the vibration of a rectangular plate having an internal crack lying perpendicular to two opposite, simply supported edges.

Other Relevant Research

A number of other recent papers [11, 79-89] relate to the vibrations of rectangular plates, and should be included for the sake of making this review more complete. Their abstracts generally contain little information to clarify the types of problems being studied.

OTHER QUADRILATERAL SHAPES

Several recent works take up the vibrations of plates of parallelogram shape [14, 36, 90-93]. Kuttler and Sigillito [90] demonstrated a method which gives both upper and lower bounds for the frequencies, is computationally like the Ritz method in that linear combinations of trial functions are optimized, but does not require the trial functions to satisfy any boundary conditions. Rather close bounds were presented for clamped rhombical plates having corner angles varying from 90° to 45° in 5° increments. Both clamped and simply supported rhombic plates were studied by Sundararajan [14] and by Nagaya [92].

Clamped and simply supported trapezoidal plates were analyzed by Nagaya [92].

TRIANGULAR PLATES

A variety of results have been found recently for vibrating triangular plates. Narita [46] determined the first six frequencies and nodal patterns for the completely clamped (CCC) equilateral triangle.

Others [27, 28, 94] found fundamental frequencies for the clamped and simply supported cases. Chander and Donaldson [41] demonstrated their "extended field method" of solution for an isosceles triangle having its base simply supported and its sides clamped. Bucco, Mazumdar and Sved [27] analyzed the CCC isoceles right triangle. Gorman [73] used the results of the diagonally supported square to find the frequencies and mode shapes of isosceles right triangles having various edge conditions. Kanaku Raju and Rao [95] gave the first three frequencies of isosceles triangular plates clamped at a single place, located at the mid, 1/3 and 1/4 points of one of the equal sides.

OTHER SHAPES

Plate shapes may be divided into two categories depending upon their boundary shape (outer boundary, in the case of a multiply connected region); that is, polygonal or curvilinear. For the former case we have already considered triangles and quadrilaterals (including rectangles); for the latter we have treated cirlces and ellipses. If any portion of the boundary is not straight, the plate will be considered curvilinear.

Irie, Yamada and Narita [96] developed the method discussed previously for simply supported rectangular plates having interior line supports [68] to accommodate clamped, regular polygonal plates. One very interesting graph shows the change in frequency parameters and associated nodal patterns as the number of sides increases from 3 to 8, and extrapolated to ∞ (clamped circle). Results are given for the first seven modes for each shape.

Laura and his colleagues [97-100] analyzed a series of problems involving regular polygonal shapes, both simply supported and clamped. Ritz-Galerkin methods were generally used, along with conformal mapping to transform the polygons to circles. The effect of an added concentrated mass was also considered [98]. Nagaya [101] dealt with regular polygonal (3-6 sides) plates having circular inside boundaries. Data was presented for various combinations of edge conditions on the two boundaries. A method using static beam functions along with Rayleigh's Quotient has been developed to analyze a number of shapes [14, 102].

Still more complicated plate configurations have been studied [103]; namely, cross-shaped, I-shaped and L-shaped plates clamped completely along their edges. Some interesting curves show the decrease in nondimensional frequency parameters of the first ten modes in each case as the widths of the sections is increased, filling up a square in the limit. Holographic interferometry was used to provide experimental checks for the I-shaped configurations [104].

Some interesting curvilinear configurations have been considered. Wilson and Garg [105] analyzed annular sectors having their radial (i.e., straight) edges simply supported and the circumferential (i.e., circular) edges free. The resulting frequencies were found to be considerably different than those predicted by curved beam theory, both for bending and twisting modes. Annular sector plates were also studied by Mukhopadhyay [106].

Circular segment plates were examined by Khurasia and Rawtani [107]. The circular boundary was clamped and the straight chord was (apparently) free. Numerical results from the finite element method were checked against experiment. Results for the clamped, semi-elliptic plate are also available [27].

Other curvilinear shapes recently considered include: (a) clamped or simply supported parabolic shapes [37]; (b) aerofoil shapes represented by two intersecting circle arcs [108]; and a plate having a clamped circular inside edge and a free outer one consisting of three arcs [109].

Simple formulas for estimating the frequencies of plates of arbitrary shape from known deflected shapes of uniformly loaded, static deflection solutions have been derived [14, 110].

SUMMARY

Observing the wealth of information on classical plate vibrations which one finds in the literature of the past four years, it is clear that this long standing subject of research is very much alive. A comparison between the two time periods covered by the previous [1] and present reviews may be made from the data in the Table below. Considering the previous

and present time periods to encompass approximately 3½ and 4½ years, respectively, it would appear that the total productivity rate per year is about the same.

However, to the credit of researchers and because of the power and availability of computational equipment and methods, the average recently published paper contains more useful numerical results than those published earlier. It is hoped that researchers will continue to avail themselves of the sources provided in these review articles, to compare their results with those of others, to fill in gaps in existing knowledge, and to improve upon their analytical, computational and experimental procedures.

Table. Comparison of Literature Sources

Shape of Plate	Number of References	
	1973 - 1976	1976 - 1980
Circular	11	27
Elliptical	8	6
Rectangular	43	55
Other Quadrilateral	9	6
Triangular	5	7
Other	9	18

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PARAMETRIC VIBRATION
PART VI: STOCHASTIC PROBLEMS (2)

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Abstract. *This article reviews recent developments and results of the theory of random parametric vibration that have been published since 1976. Part V of this series contains a survey of problems and results published through 1976. The present review is considered a complement of Part V.*

Recent developments in the mathematical theory of stochastic differential equations and of random processes have been useful in the study of dynamic systems driven by random parametric excitations. During the last five years, remarkable progress has been made in the analysis of stochastic stability of linear and nonlinear systems. In addition, new closure techniques to truncate the infinite hierarchy moments equations have been established to solve a number of problems that were regarded as difficult. The probability of the first passage time, the interaction between self-excited and random parametric vibrations, and identification of oscillating and vibro-impact systems are among the recent problems that are reviewed in this article.

DYNAMIC MOMENTS EQUATIONS

The dynamic moments equations of the response of systems subjected to white noise parametric excitation can be derived by employing the Fokker-Planck equation [1]. The Itô stochastic calculus [2, 3] is an alternative tool for deriving a general equation for the evolution of the response of dynamic moments of any order. The equations of motion of dynamic systems under white noise can be written in the form of Langvin's differential equation:

$$\frac{d\underset{\sim}{X}}{dt} = \underset{\sim}{f}(\underset{\sim}{X},t) + \underline{G}(\underset{\sim}{X},t)\underset{\sim}{W}(t) \qquad (1)$$

$\underset{\sim}{X}$ is the n-dimensional state vector of the response coordinates, $\underset{\sim}{f}(\underset{\sim}{X},t)$ is a vector function of the state variables, $\underline{G}$ is an nxm matrix function, and $\underset{\sim}{W}(t)$ is a vector of white noise or shot process. The $\underset{\sim}{W}(t)$ process is delta-correlated and does not possess a mean-square Riemann integral. The white Gaussian noise can be formally written as the derivative of Brownian motion process, B(t) as W(t) = dB(t)/dt. As a result of this definition, equation (1) can be written in the form of the Itô differential equation [2]:

$$d\underset{\sim}{X} = \underset{\sim}{f}(\underset{\sim}{X},t)dt + \underline{G}(\underset{\sim}{X},t)d\underset{\sim}{B} \qquad (2)$$

For Itô's theorem [2, 3] let $\Phi(\underset{\sim}{X},t)$ be a scalar-valued real function continuously differentiable in t and having continuous second mixed partial derivatives with respect to the elements of the vector $\underset{\sim}{X}$ governed by equation (2). Expand $\Phi(\underset{\sim}{X},t)$ in a Taylor series and take the stochastic differential, $d\Phi(\underset{\sim}{X},t)$:

$$d\Phi(\underset{\sim}{X},t) = \frac{\partial\Phi}{\partial t}dt + \left\{\frac{\partial\Phi}{\partial X_i}\right\}^T \left\{dX_i\right\} + \frac{1}{2}\,\mathrm{Trace}\,\underline{G}\,\underline{Q}\,\underline{G}^T\left\{\frac{\partial^2\phi}{\partial X_i \partial X_j}\right\} dt + \ldots \qquad (3)$$

where

$$E[\{dB_i\}\{dB_i\}^T] = \underline{Q}dt$$

T refers to transpose and E[ ] refers to expectation.

For the special case, $\Phi = \Phi(\underset{\sim}{X})$, take the expectation of both sides of equation (3) and divide it by dt to set up differential equations governing the moments of the response vector $\underset{\sim}{X}$.

Wedig [4] employed a simplifed form of equation (3) to the systems described by the linear form of equation (2) as:

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$$d\underset{\sim}{X} = \underline{A}\,\underset{\sim}{X}\,dt + \underline{C}\,\underset{\sim}{X}\,dB \qquad (4)$$

$\underline{A}$ and $\underline{C}$ are constant square matrices.

Determine the increment of the matrix process $\underset{\sim}{X}\underset{\sim}{X}^T$ by expressing the function Φ as $\underset{\sim}{X}\underset{\sim}{X}^T$. Differential calculus gives [5]

$$d\Phi = d(\underset{\sim}{X}\underset{\sim}{X}^T) = d(\underset{\sim}{X})\underset{\sim}{X}^T + \underset{\sim}{X}d(\underset{\sim}{X}^T) + d(\underset{\sim}{X})d(\underset{\sim}{X})^T \qquad (5)$$

Introduce equation (4) in equation (5):

$$\begin{aligned} d(\underset{\sim}{X}\underset{\sim}{X}^T) &= (\underline{A}dt + \underline{C}dB)\underset{\sim}{X}\underset{\sim}{X}^T + \\ &\underset{\sim}{X}\underset{\sim}{X}^T(\underline{A}^T dt + \underline{C}^T dB) + \underline{C}\underset{\sim}{X}\underset{\sim}{X}^T\underline{C}^T dt \ldots \end{aligned} \qquad (6)$$

Take the expectation and divide it by dt to obtain the following covariance equations:

$$\frac{d}{dt} E[\underset{\sim}{X}\underset{\sim}{X}^T] = \underline{A}E[\underset{\sim}{X}\underset{\sim}{X}^T] + E[\underset{\sim}{X}\underset{\sim}{X}^T]\underline{A}^T + \underline{C}E[\underset{\sim}{X}\underset{\sim}{X}^T]\underline{C}^T \qquad (7)$$

If the parametric excitation of linear systems is white noise, equation (3) will lead to a set of consistent differential equations for the moments of any order of the system response. The stochastic stability of the moments can then be analyzed. However, for linear systems under narrow-band excitation generated from white noise by means of a linear shaping filter or for nonlinear systems, the resulting moments equations are always coupled with moments of higher order. In this case, the system of moments equations forms a set of the so-called infinite hierarchy equations. A closure procedure is commonly introduced in which higher-order moments are replaced by lower-order moments. In the past few years, a number of closure techniques have been formulated and successfully used.

CLOSURE SCHEMES

The infinite hierarchy equations of a set of first-order nonlinear Itô equations can be written in the form

$$\frac{dM_i}{dt} = F_i(M_1, M_2, \ldots, M_i, M_{i+1}, \ldots) \qquad (8)$$

where $i = 1, 2, \ldots$, and $M_i\ (t=0) = C_i$. M_i are the exact solutions of the infinite set. All truncation schemes reduce the system of equation (8) to a finite set of the form:

$$\frac{dm_i}{dt} = G_i(m_1, m_2, \ldots m_N) \qquad (9)$$

where $i = 1, 2, \ldots, N$ and $m_i\ (t=0) = b_i$. Here m_i are the approximate solutions after truncation. Truncation of the system of equation (8) is valid if the resulting error $(M_i - m_i)$ is very small such that *the moment properties* are preserved. Bellman et al. [6, 7] established two lemmas that guarantee the moment properties.

Cumulant truncation scheme. For the random vector $\underset{\sim}{X} = (X_1, X_2, \ldots, X_n)$, the characteristic function $\phi_{\underset{\sim}{X}}(\underset{\sim}{\theta})$ is defined as the Fourier transform of the probability density function [8]. The joint moments of $\underset{\sim}{X}$ can be obtained in terms of the derivatives of $\phi_{\underset{\sim}{X}}$; i.e.,

$$E[X_1^{k_1} X_2^{k_2} \ldots X_n^{k_n}] = \frac{1}{i^K} \frac{\partial^K}{\partial\theta_1^{k_1} \ldots \partial\theta_n^{k_n}} \phi_{\underset{\sim}{X}}(\underset{\sim}{\theta}) \Big|_{\underset{\sim}{\theta}=0} \qquad (10)$$

where $K = k_1 + k_2 + \ldots + k_n$. The joint cumulant κ of order K is given by

$$\kappa[X_1^{k_1} X_2^{k_2} \ldots X_n^{k_n}] = \frac{1}{i^K} \frac{\partial^K}{\partial\theta_1^{k_1} \ldots \partial\theta_n^{k_n}} \ln \phi_{\underset{\sim}{X}}(\theta) \Big|_{\underset{\sim}{\theta}=0} \qquad (11)$$

The definition of equation (11) and the relation of equation (10) reveal that the joint cumulant of order K is related to the Kth and lower joints moments. If the vector $\underset{\sim}{X}$ has Gaussian distribution, it follows from the form of the characteristic function that all cumulants of order $K > 2$ vanish identically. This will lead to moments of order greater than two in terms of the first and second moments.

In linear systems it is known that the response is Gaussian distributed if the external excitation is Gaussian. Bolotin [9] has employed this property and assumed that higher-order moments are related to lower-moments by the multi-dimensional Gaussian process relations, with the cumulant of the corresponding order equated to zero. In two other papers [10, 11], Bolotin and Moskvin introduced a similar procedure based on a quasi-Gaussian assumption. It was assumed that all moments of odd order greater than r (r is the highest order of moments to be retained in the analysis) are set to zero. Moments of even order $2S (2S > r)$ are related to the moments $m_{ijk}(t)$ by the formula:

$$m_{ijl\ldots}(t) = \Sigma m_{k_1,k_2} m_{k_3,k_4} \ldots m_{k_{2S-1},k_{2S}} \qquad (12)$$

where $m_{ijl} = E[X_iX_jX_l]$. The summation in equation (12) contains all possible partitioning of 2S subscripts $k_1, k_2, \ldots k_{2S}$ (including recurring) into S pairs $k_1k_2, k_3k_4, \ldots, k_{2S-1}k_{2S}$.

For systems with small nonlinearities subjected to Gaussian excitations, the joint distribution functions of the response may not deviate significantly from Gaussian form. However, this approximation was the subject of a controversy during an IUTAM Symposium [12] for the errors arising from the use of Gaussian closure in a number of examples. In a number of situations the application of the cumulant closure violates the moments properties [13].

Central moments method. The joint central moments μ_K for the vector $\underset{\sim}{X}$ are given by:

$$\mu_K = E[(X_1-m_1)^{k_1}(X_2-m_2)^{k_2}\ldots(X_n-m_n)^{k_n}] \quad (13)$$

where $m_i = E[X_i]$.

The joint central moments up to order three are identical to the first three joint cumulants. They differ beyond the third order. The basis for truncation lies in setting the joint central moments to zero beyond a selected order. This approach has been found to be less accurate than the cumulant scheme [6]; the accuracy of the latter is explicable from the fact that the assumption of zero valued central moments beyond a certain order has no basis, even in the case of a Gaussian distribution.

Mean-square closure technique. Bellman et al [6, 7] and Sancho [14, 15] have analyzed a number of nonlinear Itô-stochastic differential equations with a single variable. They introduced a closure scheme based on a mean-square minimization technique to reduce the infinite hierarchy system of equation (8) to a finite one. The higher-order moments are written as functions of lower-order moments:

$$m_{n+1} = \sum_{i=1}^{n} a_{in}m_n, \qquad \text{where } m_n = E[X^n] \quad (14)$$

The procedure applies to the requirement that the mean-square error

$$e = \int_0^\infty (m_{n+1} - \Sigma\, a_{in}m_n)^2 dt$$

be minimized with respect to the quantities a_{in}, which are to be constants restricted by the condition that Bellman's lemmas [6, 7] be satisfied for one-dimensional cases. For multi-dimensional systems, the method becomes tedious.

Non-Gaussian closure. Crandall [16] introduced a closure technique based on a non-Gaussian probability density distribution. The method suggests the following truncated Gram-Charlier expansion for the probability density:

$$p(x) = \frac{\exp\{\frac{(X-m)^2}{2\sigma^2}\}}{\sqrt{2\pi}\,\sigma}\{1 + \sum_{n=3}^{N} \frac{C_n}{n!} H_n\left(\frac{X-m}{\sigma}\right)\} \quad (15)$$

Terms in the summation represent departure from the Gaussian distribution. The N parameters of equation (15) are the mean m, the standard deviation σ, and the coefficients $C_3, C_4, \ldots, C_N$. H_n are the Hermite polynomials. The coefficients C_n are evaluated as expectations of Hermite polynomials:

$$C_n = E[H_n(\frac{X-m}{\sigma})] \qquad n=3,\ldots,N \quad (16)$$

$$E[H_n(\frac{X-m}{\sigma})] = \begin{cases} 1 & n=0 \\ 0 & n=0,2 \\ 0 & n=N+1, N+2, \ldots \end{cases} \quad (17)$$

The distribution given by equation (15) can be used for evaluating moments $E[X^n]$ and expectations of polynomial functions of X because any power of X can be represented as a linear combination of Hermite polynomials. The expectations of Hermite polynomials are given by equations (16) and (17). The N parameters in equation (15) are evaluated by first deriving relations between the system response statistics. The response statistics are obtained by multiplying the system equation of motion by functions $\psi(X)$ and taking the expectation of each term.

The procedure is carried out by fixing the order N, obtaining N constraints on the distribution by using the derived statistical relations, and using these constraints to evaluate the parameters in equation (15). With these parameters fixed, the approximate probability density of the stationary response is given by

equation (15), and any desired statistic that depends on p(X) can be calculated.

Lie algebra closure method. This closure method is applicable only for linear sytems described by the first-order differential equations:

$$\dot{\underset{\sim}{X}} = \{\underline{A} + \underline{B}\underset{\sim}{f}(t)\}\underset{\sim}{X} \tag{18}$$

$\underline{A}$ and $\underline{B}$ are square matrices and $\underset{\sim}{f}$ is a vector of colored noise process whose elements are stationary Gaussian with zero mean. The method depends on the structure of the Lie algebra generated by the matrices $\underline{A}$ and $\underline{B}$ [17, 18]. Closed moment equations have been given by Sagirow [18] for the case of an Abelian Lie algebra (with $\underline{AB} = \underline{BA}$). For the case of a general Lie algebra, Kistner [19] outlined a scheme for deriving closed first- and second-order moment equations. The method is based on expressing the solution $\underset{\sim}{X}$ in a series expansion that is used to calculate the equations for the first- and second-order moments of $\underset{\sim}{X}$. The mathematical details of the method, together with its application to simple systems, have been given [19, 20].

SINGLE DEGREE-OF-FREEDOM SYSTEMS

The behavior of dynamic systems under random parametric excitations is discussed under two classes: systems with a single degree-of-freedom and systems with many degrees-of-freedom. The dynamic behavior of single degree-of-freedom systems subjected to random parametric and external excitations can be described by the dimensionless differential equation:

$$\begin{aligned} &\ddot{X} + [2\zeta+f_1(\tau)]\dot{X} + [1+f_2(\tau)]X + \\ &\phi(\ddot{X},X) + \psi(\dot{X},X) + \theta(X) = f_3(\tau) \end{aligned} \tag{19}$$

where $f_1(\tau)$, $f_2(\tau)$, and $f_3(\tau)$ are random excitations; the functions Φ, ψ, and θ represent inertia, damping, and stiffness nonlinearities respectively. The linear damping ratio is ζ, and dots denote differentiation with respect to dimensionless time τ. Systems treated in the literature are described by special forms of equation (19) and are classified as linear or nonlinear systems.

Linear systems. Within the framework of the linear theory many systems can be modeled by the Mathieu-Hill stochastic equation:

$$\ddot{X} + 2\zeta\dot{X} + [1-\varepsilon f_2(\tau)]X = 0 \tag{20}$$

where ϵ is the coefficient of parametric excitation. Moskvin [21] examined the stochastic stability of equation (19) for the case of filtered white noise random excitation $f_2(\tau)$ with respect to a set of moments. The stability of a truncated set of response moments up to third order has been treated by Bolotin and Moskvin [10, 21]. For the case of white noise excitation, the stability of higher-order moments (up to order 20) has been analyzed by Moskvin and Smirnov [22]. The domain of stability of third-order moment was given by the following two conditions:

for very small ζ

$$\varepsilon^2 D_2 < 4\zeta^2(4 + 37\zeta^2 + 40\zeta^4) \tag{21}$$

for large ζ

$$\varepsilon^2 D_2 < (1 + 8\zeta^2)/4\zeta \tag{22}$$

D_2 is the spectral density of $f_2(\tau)$.

For small damping ratio ζ, the transition from a stable to an unstable state corresponds to an oscillatory change of third-order moments. For large ζ, the change of the third-order moments near the boundary of the instability domain is quasi-monotonic in nature.

One remarkable feature of the stability of higher-order moments is that the stability becomes more restrictive with increasing order of the moment. This fact is mathematically well known and has been discussed by Willems [23]. The physical interpretation of higher moments stability would be difficult, due to the fact that these higher moments (of order greater than two) have no physical meaning. According to Willems, the more restrictions given to higher moments of a process, the more moderate the behavior of the examples of the process will be.

Gopalsamy [24] used the perturbation theory of semi-groups of operators to obtain a sufficient condition for the mean-square stability of a class of randomly linear systems. These systems are governed by a generator of a contraction semi-group

of bounded linear operators. A probability bound was obtained for the perturbed system to be asymptotically stable.

The dynamic behavior of a single-mass damped vibro-impact oscillator with two symmetrical barriers with respect to the equilibrium position has been investigated by Dimentberg and Menyailov [25]. For the case of white noise parametric excitation, the equation of motion between impacts [25] is

$$\ddot{X} + 2\zeta\dot{X} + [1-f_2(\tau)]X + (\dot{X}_+ + e\dot{X}_-)\delta(\tau-\tau^*) = 0 \quad (23)$$

where e is the coefficient of restitution, $\dot{X}_+ = -r\dot{X}_-$, $\dot{X}_\pm = \dot{X}(\tau^*\pm 0)$, and the time of impact τ^* is determined by the condition $X(\tau^*) = \pm\pi/2$. The vibro-impact system described by equation (23) is considered quasi-conservative for small values of ζ, (1-e) and the spectral density D_2 of $f_2(\tau)$. For that system, two possible types of motion are possible: oscillations without impact and oscillations with alternative impacts on both barriers. In both types the random vibration during each cycle would be close to the natural oscillations of the corresponding conservative system, and the total energy E of the system would be a slowly varying function of time.

For the case $e < 1$, a stationary probability distribution of the energy of the response exists if

$$8\zeta/D_2 << 1 \quad (24)$$

If condition (24) is violated, the system will have no response.

For impact with one barrier, another condition for stationary probability was obtained:

$$\pi(\frac{1}{8} D_2 - \zeta) < (1-e) \quad (25)$$

where $(\frac{1}{8} D_2 - \xi)$ is the effective increment of a stochastically unstable linear system. The behavior of the system with one barrier differs from that of two barriers, provided a probability distribution of the response energy always exists, for two reasons: in the two-barrier case the excitation level is limited, but it is not in the one-barrier case; and the ratio of dissipated energies due to delta-type impact damping and viscous damping are qualitatively different for systems with one- and two-impact barriers because of the different behaviors of the phase trajectories in the corresponding conservative systems.

Katsnel'son et al. [26] outlined an approximate method that uses the perturbation technique to examine the stochastic stability of linear systems under two stationary narrow-band parametric excitations represented by the differential equation:

$$\ddot{X} + \varepsilon[2\varepsilon\zeta + f_1(\tau)]\dot{X} + [1+\varepsilon f_2(\tau)]X = 0 \quad (26)$$

The stability of equation (26) was examined under the monotone decrease of the mean-square condition:

$$E[X^2(0)] > E[X^2(T)] > E[X^2(2T)] > \ldots \quad (27)$$

where the period $T \simeq \frac{1}{\epsilon}$. Averaging was performed over a set of initial conditions with respect to both realizations of the random processes $f_1(\tau)$ and $f_2(\tau)$ and the phase of the response. Secular terms that emerge from the integration process take place at the singular points of zero and twice the natural frequency of the system. The procedure led to the following stability condition:

$$4\zeta > D_2(2\omega) + D_1(2\omega) + D_1(0) - 2\,\mathrm{Im}D_{12}(2\omega) \quad (28)$$

where D_1, D_2, and D_{12} are the spectral densities of f_1, f_2, and $f_1 f_2$, respectively. If $f_1(\tau) = 0$, condition (28) takes the form of the well-known condition:

$$\zeta > D_2/4 \quad (29)$$

When the linear system of equation (19) is acted upon by the three white noise excitations f_1, f_2, and f_3, the mean square of the response is given by the solution [27]:

$$E[X^2] = \frac{D_3}{4\zeta - D_1 - D_2} \quad (30)$$

Mirkina [28, 29] employed the method of the multiple-scale expansion to determine the response and stochastic stability of the homogeneous linear system of equation (19) under $f_2(\tau)$ only. The equation of motion of the system was written in the form:

$$\ddot{X} + 2\varepsilon^2\zeta\dot{X} + [1+\varepsilon f_2(\tau,\varepsilon\tau)]X = 0 \quad (31)$$

The stationary function $f_2(\tau, \epsilon\tau)$ is regarded as a function of the fast time variable τ, as well as of the slow variable $\epsilon\tau$. The mean square solution of equation (31) was given in the form:

$$E[X^2(\tau,\varepsilon)] = \frac{1}{2} E[X^2(0)+\dot{X}^2(0)] \{1 + [\frac{1}{2} D_2(2\omega)-2\zeta]\varepsilon^2\tau\} + \ldots \tag{32}$$

The stability conditions of the response root mean squares were found to be identical to those derived by Alekseyev and Valeev [30] as

$$\left.\begin{aligned} 4\zeta &> D_2(2\omega) - D_2(0) \\ 4\zeta &> D_2(2\omega) \end{aligned}\right\} \tag{33}$$

The stability map obtained by Mirkina [29] is similar to that obtained by Bolotin and Moskvin [10] and exhibits the V-shape at the principal and secondary resonances.

Recent studies have included the probability of analysis of the first passage of linear systems under random parametric excitations [31, 32]. Dimentberg and Sidorenko [31] examined the probability of the first passage of a linear system acted upon by the stationary random excitations $f_2(\tau)$ and $f_3(\tau)$. The solution of the stationary Fokker-Planck equation exhibits a sharp drop in the probability of the first passage as a result of the parametric excitation. The reason for that drop is attributed to the fact that the system approaches the boundary of the stability region. Such influence becomes remarkable as the threshold amplitude level increases as shown in Figure (1). The level of parametric amplification of the response due to $f_3(\tau)$ was evaluated by separating the sources of oscillations.

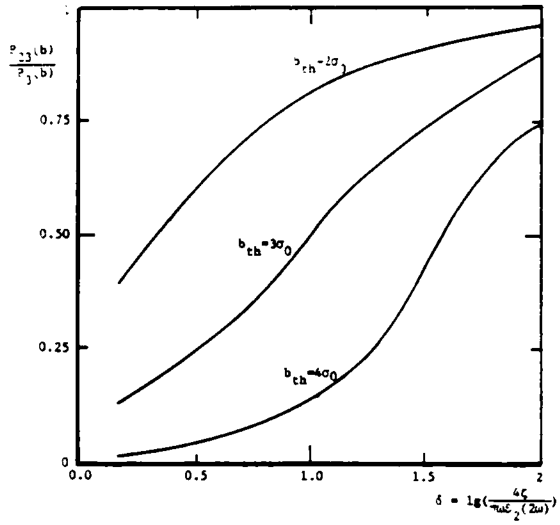

Figure 1. Variation of the first passage probability with the excitation parameter δ for various values of the threshold amplitude b_{th}. $[\sigma_0 = \frac{\pi S_3(\omega)}{2\zeta\omega^3}$, $P_{23}(b)$ = **first passage probability due to parametric and external excitations, $P_3(b)$ = Probability due to external excitation only,**

$$\ddot{X} + 2\zeta\omega\dot{X} + \omega^2[1+f_2(\tau)]X = f_3(\tau)] \quad [31]$$

Ariaratnam and Tam [32] considered similar systems under the influence of the three stationary random excitations f_1, f_2, and f_3. These excitations were assumed to have arbitrary spectral densities with small correlation. The application of the stochastic averaging method of Stratonovich and Khasminiskii led to the moments of the response coordinates. Stochastic stability was found to be affected at those values of spectral densities of parametric excitations corresponding to zero and twice the system natural frequency. The external excitation had no effect on stability. The analysis included conditions for simple or almost sure asymptotic stability of a system under the two parametric excitations f_1 and f_2. Results were correlated with those of Mitchell and Kozin [33]. The probability of the first passage time for envelope crossing were derived using the Kolmogorov equation following the scheme of Ariaratnam and Pi [34].

Renger [35] analyzed the joint probability distribution of a vibratory linear system subjected simultaneously to Gaussian white noise and random impulses (with $f_1(\tau) = f_2(\tau) = 0$). The evolution of the probability distribution was described by a partial integro-differential equation that can be regarded as a generalization of the Fokker-Planck equation to Markov processes without diffusion character. The analysis was extended to determine the stochastic stability of a column subjected to axial shot noise $f_2(\tau) = \epsilon N(\tau)$ and led to the condition:

$$\zeta > \frac{\nu\varepsilon^2 A^2}{4(1-\nu\varepsilon A)} \tag{34}$$

where ν is the expectation of the time rate of number of shots $n(E[n] = \nu d\tau)$. A is the mean value coefficient of the characteristic function of the vector $(X, \dot{X})$.

The random parametric vibrations of beams and plates [36], shells [37], and shafts [38] have been analyzed to determine the regions of dynamic instability. Kul'terbaev [39] examined the stochastic stability of the stationary response of a flexible hollow cylindrical panel subjected to a random axial force applied to the curvilinear edge. The dependence of the stationary mean $E[X]$ and the standard deviation σ_X upon the broadband random excitation exhibited by parameter ξ is that of higher values of ξ. There are two possible responses: oscillations about the snap-through and motion about a non-snap through state. The transition from one stable stationary response to another one takes place for suitably slow changes of a wide-band parameter.

Nonlinear systems. The identification problem of oscillating systems with nonlinear damping subjected to parametric and external excitations has been studied by Dimentberg and Gorbunov [39, 40]. The following system was considered [39]:

$$\ddot{X} + 2\zeta\dot{X} + \beta\dot{X}^3 + [1+\varepsilon \cos 2\tau]X = f_3(\tau) \quad (35)$$

The response of the system of equation (35) was obtained by carrying out the averaging process in accordance with the Krylov-Bogolyubov method. The result was a system of truncated equations in X_1 and X_2($X = X_1 \cos \tau + X_2 \sin \tau$). The stationary solution of the Fokker-Planck equation of the truncated system was used to solve two diagnostic problems: estimating the threshold of parametric instability by measuring the random oscillations and identifying oscillations caused by external and parametric sinusoidal disturbances. The identification of self-excited vibration when $f_2(\tau)$ and $f_3(\tau)$ are both random was considered [39].

Another analysis [40] can be used to establish the predominant mechanism of self-excitation in such mechanical systems as thin rods subjected to a longitudinal flow of liquid with turbulent pressure pulsation [41]. Chen and Weber [42] suggested that the mechanism of periodic parametric excitation is a result of turbulent pulsations of friction forces that play the role of a distributed follow-up longitudinal load on the rod. The periodicity assumption was discussed by Dimentberg [40] who established an alternative analysis based on the random nature of parametric processes of the turbulent velocity pulsation.

The dynamic behavior of a nonlinear system subjected to a broadband random parametric excitation has been examined by Ibrahim and Roberts [13, 43]. They considered a system described by the differential equation:

$$\ddot{X} + 2\zeta\dot{X} + [1-f_2(\tau)]X + \alpha X(X\ddot{X}+\dot{X}^2) + \beta X^2\dot{X} + \gamma X^3 = 0 \quad (36)$$

where α, β, and γ are the (small) nonlinear inertia, damping, and stiffness coefficients respectively. The moment equations of the system response coordinates were derived by the Fokker-Planck equation [13]; by the Itô stochastic calculus [43] the moment equations were found identical and formed an infinite hierarchy set. The following closed form mean squares of the response displacement were obtained after truncation of the moment equations:

effect of nonlinear inertia

$$E[X^2] = \frac{1}{6\alpha}\frac{(D_2-2\zeta)}{(D_2-\zeta)} \quad (37)$$

effect of nonlinear stiffness

$$E[X^2] = \frac{1}{3\gamma}\left(\frac{D_2}{2\zeta} - 1\right) \quad (38)$$

effect of nonlinear damping

$$E[X^2] = \frac{1}{\beta}\left(\frac{D_2}{2\zeta} - 1\right) \quad (39)$$

These results are valid if $D_2 > 2\xi$ and are bounded if α, γ, and β do not vanish.

Kul'terbaev [37] considered quadratic and cubic stiffness nonlinearities in the equation of motion of a cylindrical panel under random axial excitation. The response moment equations were obtained by the method of spectral representation used by Bolotin [9-11]. The moment equations were truncated by using the quasi-Gaussian assumption; the result was two nonlinear algebraic equations for the mean and the variance of the stationary response.

MULTI-DEGREE-OF-FREEDOM SYSTEMS

Linear systems. Linear systems with two degrees of freedom have been investigated by a number of re-

searchers [4, 11]. These systems are described by the coupled differential equations:

$$\left.\begin{aligned} \ddot{X}_1 + 2\zeta_1\omega_1\dot{X}_1 + \omega_1^2[X_1+\epsilon f(\tau)(a_{11}X_1+a_{12}X_2)] = 0 \\ \ddot{X}_2 + 2\zeta_2\omega_2\dot{X}_2 + \omega_2^2[X_2+\epsilon f(\tau)(a_{21}X_1+a_{22}X_2)] = 0 \end{aligned}\right\} \qquad (40)$$

where a_{ij} are the intensity constants. For the case of white noise excitation $f(\tau)$, Wedig [4] employed the method of averaging and obtained the stability condition:

$$(4\zeta_1\omega_1-a_{11}^2)(4\zeta_2\omega_2-a_{22}^2) - a_{12}^2a_{21}^2 + \ldots > 0 \qquad (41)$$

Condition (41) is an approximation, and extra terms would be required if the damping is large.

For narrow-band excitation $f(\tau)$ generated by passing a white noise through a second-order shaping filter, Bolotin and Moskvin [11] applied the Fokker-Planck equation to the state vector together with the quasi-Gaussian closure hypothesis and obtained 22 coupled moment equations in terms of the first- and second-order moments of the response coordinate in the form

$$\dot{\underset{\sim}{m}} = \underline{A}\underset{\sim}{m} \qquad (42)$$

A is a 22 x 22 square matrix. The boundaries of the stability region were obtained numerically by solving the characteristic equation of condition (41). $\det(\underline{A} - \lambda\underline{E}) = 0$ onto the unit circle by using the substitution $\lambda = (\sigma-1)/(\sigma+1)$. In this case, the characteristic equation becomes $\det(\underline{G} - \sigma\underline{E}) = 0$, where $\underline{G} = (\underline{F} - \underline{E})^{-1}(\underline{F} + \underline{E})$ and $\underline{E}$ is the identity matrix. The trivial solution of equation (42) will be asymptotically stable if all the roots σ_i lie within a circle of unit radius. For a Hamiltonian system (with $a_{11} = a_{22} = 0$), the stability region corresponding to the combination resonance $\Omega = |\omega_1+\omega_2|$ is shown in Figure (2).

Willems [23, 44] applied the Lie algebra theory to the moment stability of linear systems excited

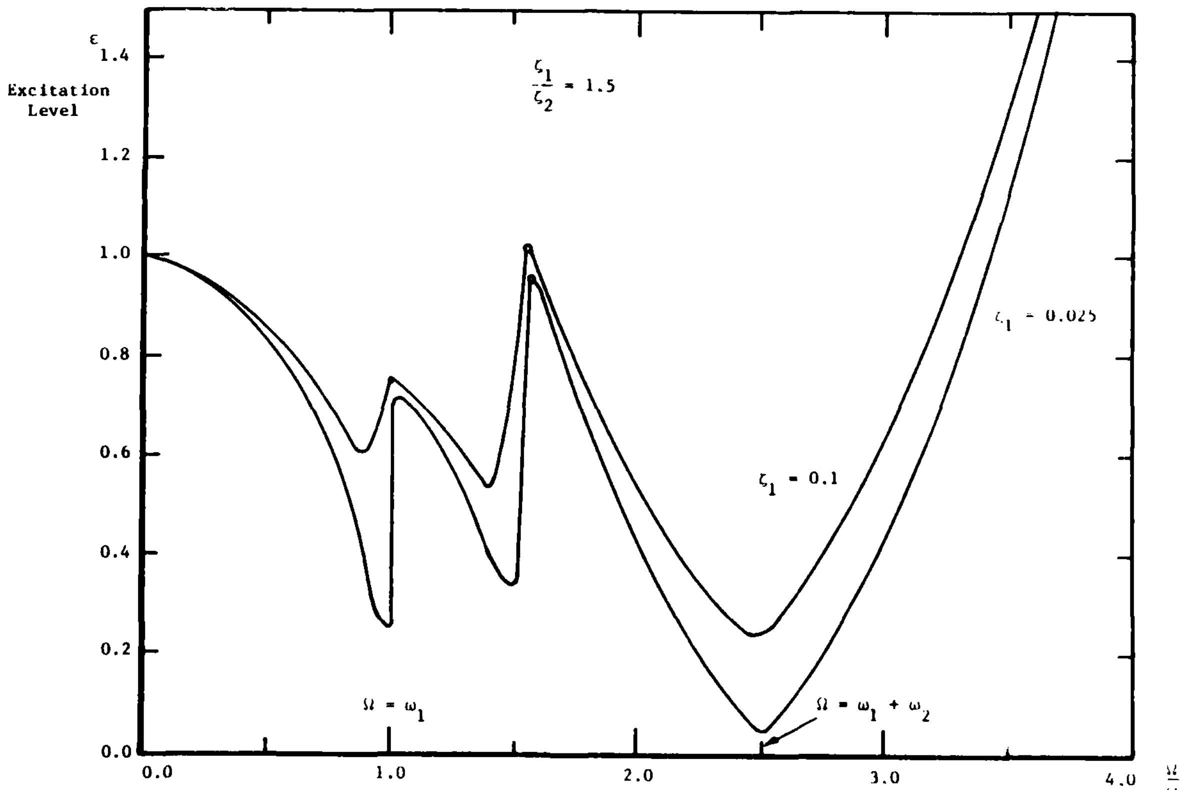

Figure 2. Stability Boundaries of a Two-Degree-of-Freedom System [11] ($a_{11} = a_{22} = 0, a_{12} = a_{21} = 1$)

parametrically by colored or white multiplicative noise. For colored noise excited systems, the stability conditions that depend only on the values of the excitation spectral densities at zero frequency were obtained [44]. The Lie algebra analysis fails, however, to predict stability conditions in terms of the spectra at twice the natural frequency of the system. For white noise excitation, the stability of the n-th moments of systems governed by the Itô equation were obtained using a Liapunov approach.

Dimentberg and Isikov [45] considered a multi-degree-of-freedom system, simultaneously excited by periodic parametric and random external excitations. The probability densities and mean squares of the responses in the neighborhood of principal and combination resonances were derived by using the first approximation of the Krylov-Boglyubov asymptotic method together with the averaging method of Khas'miniskii. For the case of narrow-band external excitation generated by a second-order filter, the analysis indicated that a reduction in the band width of the excitation spectrum would lead to an increase in the degree of irregularity of the phase distribution as well as in the mean-square amplitude. The results of that investigation were utilized to solve a number of identification problems similar to others listed [39].

Nonlinear systems. Recent investigations of multi-degree-of-freedom systems involving nonlinear coupling are few. They are directed toward the determination of the probability density, joint correlation, and stochastic stability of response in the neighborhood of autoparametric or combination resonance conditions. Schmidt [46] derived the probability density of the response of a two-degree-of-freedom system with autoparametric coupling under a broad-band random excitation. The Fokker-Planck equation, together with the averaging method, yielded a two-dimensional stationary probability density for the system response. The results showed that higher values of the probability density of large first mode amplitude corresponds to lower values of the probability of large amplitude of the second mode. This feature is similar to the characteristics of the autoparametric vibration absorber [1].

The autoparametric vibration absorber was recently investigated by Roberts [47]. Two stability approaches were analyzed. The first approach is based on a Gaussian closure scheme applied to the system moment equations. The stability condition is then determined from the eigenvalues of a four-by-four matrix. The second approach is based on a perturbation solution that led to an analytical expression for the stability boundary. The validity of the two approaches was examined experimentally in the neighborhood of internal resonance. It was demonstrated that experimental results give a wider instability region than those obtained analytically, especially as the internal detuning departs from the exact resonance condition as shown in Figure (3).

Model [48] investigated the combination resonance of a nonlinear vibrating system excited parametrically by a narrow-band random excitation. Stiffness and damping nonlinearities were considered, and the method of integral equations was employed. The analysis gave expressions for the probability densities of response amplitudes. Figure (4) shows the probability density of a two-degree-of-freedom system in the neighborhood of combination resonance of the sum type.

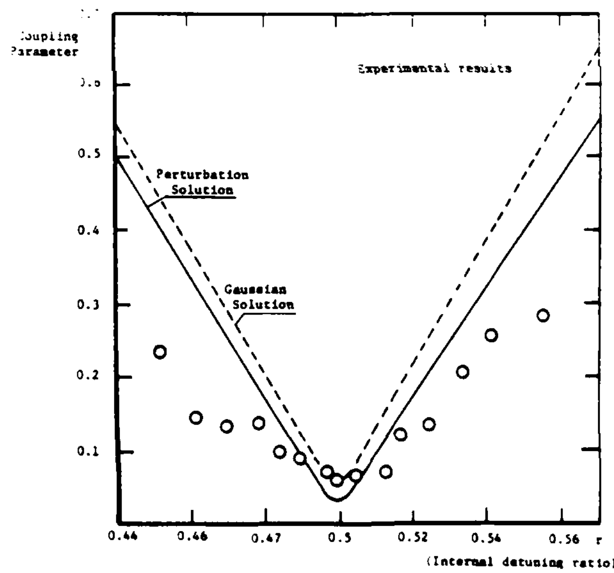

Figure 3. Stochastic Stability Boundaries of Unimodal Response of a Two-Degree-of-Freedom System with Autoparametric Coupling, ζ_1 = 0.0085, ζ_2 = 0.003 [47]

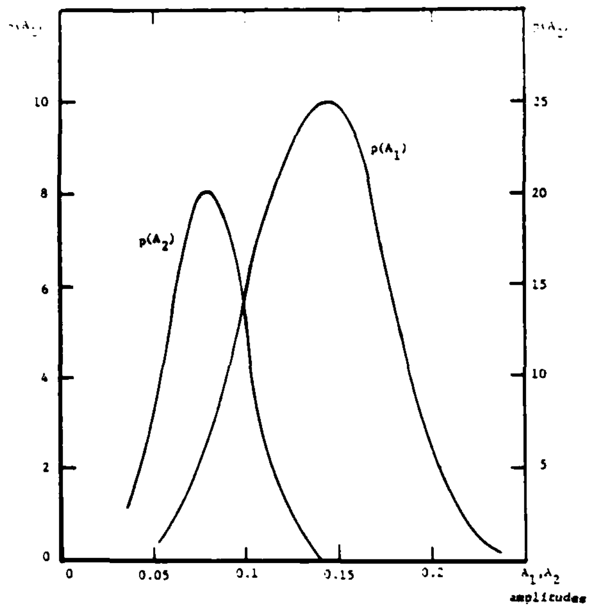

Figure 4. Probability Densities of Normal Mode Amplitudes of a Two-Degree-of-Freedom System with Nonlinear Damping and Parametric Combination Resonance [48]

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BOOK REVIEWS

MODELING AND ANALYSIS OF DYNAMIC SYSTEMS

C.M. Close and D.K. Frederick
Houghton Mifflin Co., Boston, MA
1978, 660 pages

The purpose of this book is to provide engineering students with a general interdisciplinary introductory course in system dynamics. To this end an entire chapter is devoted to each of the following systems: mechanical, electrical, electromechanical, thermal, and hydraulic. Basic physical laws are stated clearly and succinctly. The application of these laws to construction of the mathematical equations that govern the behavior, first of individual elements and then of entire systems, is illustrated with a large number of worked examples. The examples have been carefully chosen; the presentation is lively but not superficial. The student reader will find that most of his difficulties have been anticipated.

The chapters that deal with the different types of dynamical systems are interspersed with those that develop techniques of analysis. An introductory chapter defines the terms of reference for the book and states its objectives. These are, in brief: to formulate an idealized mathematical model from the physical description of a given system; if necessary, to linearize the governing equations; and to determine the behavior by solving the equations for various inputs.

The second and fourth chapters introduce mechanical systems in which motion is first purely translational and then both rotational and translational. In Chapter 3 are shown representations of the mathematical equations in state-variable form and as a single differential equation relating output to input. This dual approach is maintained throughout the book.

The next three chapters are concerned with mathematical and computational techniques. Chapter 5 has to do primarily with the development of a linear model for a system in which one or more elements are in fact nonlinear in their behavior. It concludes with a brief reference to systems that incorporate linear time-varying elements. The reader is then introduced to simulation diagrams that represent state-variable equations and input-output equations. Chapter 7 deals with the numerical solution of equations. Euler's method is discussed in detail, and its implementation on the computer is described. Errors are discussed briefly, and a brief introduction is given to other integration methods such as Runge-Kutta and predictor-corrector methods.

The analytical solution of the equation for first and second order linear systems and the general properties of such systems are treated in Chapter 8 and applied in the following chapter to linear electrical circuits. Nonlinear and time-varying circuits are considered separately in Chapter 10. A study of such electromechanical devices as microphones and electric motors follows.

Chapter 12 states the case for using the Laplace transform to solve system equations and defines it with great clarity. The authors confine their presentation to information that is useful in the context of the book; the reader is referred elsewhere for a full treatment of such matters as convergence. All the required basic transforms are evaluated, and inversion is explained in detail. The chapter concludes with statements, without proof, of the initial-value and final-value theorems. The application of the Laplace transform is extended in Chapter 13 through a reappraisal of concepts introduced in Chapter 8; the transfer function is defined and its properties explained.

Chapters 14 and 15 on thermal and hydraulic systems allow for the consolidation of earlier ideas on practical applications. Chapter 16 combines the simulation diagram and transfer function to introduce the block diagram as a way to represent feedback systems. The authors use a positional servomechanism as an example and, having investigated the way in

which the performance of the system as a whole depends on the properties of its elements, demonstrate how the performance can be improved.

The general form of state-variable mathematical models is such that matrix notation and algebra are particularly apt. Chapter 17 demonstrates this. The reader is assumed to have a working knowledge of matrix algebra but is provided with a summary of the elements of the subject in an Appendix. Computational detail is avoided by limiting discussion to low order systems, for which simple methods of matrix inversion are sufficient. Many students will find the chapter an interesting way to integrate the ideas introduced in earlier chapters.

The book concludes with a presentation of five case studies: an electromagnetic accelerometer, a tunnel diode, a velocity-control system, a temperature-control system, and a sociological system.

The succinct and elegantly written introductory paragraphs to each chapter are a particularly pleasing and helpful feature. This book can be recommended both as a course book and as a work of reference.

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BASIC INDUSTRIAL HEARING CONSERVATION

D.F. Barr and R.K. Miller
Fairmont Press, Atlanta, GA
1979, 142 pages, $26.95

This is one of many books published by Fairmont Press, a firm that seems to market copy written only by R.K. Miller and his associates. As a result the book is similar in both style and attention to detail to many other Fairmont Press publications. Unfortunately, after having reviewed several of these books, I find much lacking and little to recommend in the series in general and this book in particular. I shall elaborate in the following paragraphs.

According to the dust jacket, this book "takes the reader from the very basic concept of decibels to more advanced topics such as noise-related hearing disorders and statistical sampling techniques." Thus, I presume that Basic Industrial Hearing Conservation was meant to be used as either a classroom text for students, a self-study book for those who want or need to learn the field, or a reference for those seeking information about industrial hearing conservation. In any case the book should have adequate explanations of important topics, clear and illustrative figures, high quality references, and a well-written text. It is on these criteria that I base this review.

Basic Industrial Hearing Conservation consists of nine chapters, a glossary, and a single appendix curiously labeled Appendix A. The chapter titles are as follows: Noise - The Problem, The Nature of Sound, The Hearing Mechanism, The Measurement of Hearing, Noise Related Hearing Disorders, In Plant vs Contract Hearing Conservation Programs, Hearing Protective Devices, and Engineering Control of Noise. The appendix is an outline of a model industrial audiometric technician course. There is no index.

Although the table of contents includes most of the topics necessary to meet the book's stated goals, the subjects are not given adequate treatment. Furthermore, the authors write in the third person, as if disclaiming any involvement with the information.

The major impetus for many industry hearing conservation programs has been the Occupational Safety and Health Act. Thus, it should be described correctly. The authors are not correct when they state that ". . . specific penalties for violations were spelled out in this act . . . (and that) also specific are the instrumentation and methods of evaluation of the data obtained." Only some maximum penalties are stated, and instrumentation/evaluation methods are not mentioned. In fact, one reason for much of the controversy over the section 6 promulgated noise regulation (29 CFR 1910.95) is the lack of specificity of instrumentation and required data. At any rate, the references to the OSHA noise regulation are out-of-date: the new OSHA hearing conservation amendment was promulgated on January 16, 1981.

Some of the data presented by the authors are of questionable value. For example, they cite a study

which states that, in the iron and steel industry, 35% of workers in noisy areas had 15 or more accidents compared to fewer than 5% in quieter areas. The data were cited to show the harmful effects of noise. But that data could just as well result from the fact that noisy areas often are hazardous areas, independent of the noise level.

The authors do a sloppy job of explaining sound. They introduce the term molecular displacement of a sound wave and do not explain it. They capitalize the first letter in the term used for "cycles per second" ("Hertz" should be "hertz") and write: "the area of a sphere increases proportionately with the increase in the distance from the source," a statement that can only confuse. They tend to be careless in using esoteric terms; decibel level, for instance, is used instead of sound level, and loudness is described in the popular sense but not in the technical sense. They write that an A-weighting filter is used to "correct direct noise levels to the levels heard by the ear." I do not see how the authors can claim that "the A-weighting curve approximately matches the 40-phon curve . . . " because the two are more like mirror images of each other. More important, for a hearing conservation program I believe that A-weighting should be rigorously and unambiguously explained because it is the major metric measure used to determine the necessity for a program.

Tables and figures are poorly explained. The word center in the term center frequency of octave bands is not explained. The authors label a graph "displacement - time graph of a sound wave," but both axes are denoted as displacement. Contrary to statements in the book, the A-weighting correction factors do not in themselves convert octave band sound pressure levels to A-weighted sound levels. Rather, the corrected levels must be combined first, a fact the authors neglected to mention.

In the chapter dealing with in-plant versus consultant hearing conservation programs, references to the authors' own work lead to an obvious implication. In this chapter outdated references are cited; e.g., the Department of Labor's Guidelines to Noise Standard Bulletin 334, revised in 1971, was withdrawn by DOL several years ago.

The section on engineering control of noise is not much better. To write that sound transmission class is a "single numerical average of the barrier's transmission loss performance" is to miss the point of what STC is about and can be misleading. To write of potential core and viscoelasticity and so-called decay rate equations with little explanation or application does little to help the reader. The authors do present some easily understandable noise control solutions in this chapter but not enough to make the chapter worthwhile.

Finally, Barr and Miller state in the glossary that the audible range is 20 cycles through 20,000 cycles. The reader of Shock and Vibration Digest might know what is meant, but I doubt if the uninitiated reader does. In the glossary OSHA is defined as the Occupational Safety and Health Agency!

I recommend that the reader obtain a copy of the OSHA noise regulation and of the hearing conservation amendment and follow them in order to meet OSHA's requirements for hearing conservation programs. Any interpretations must come from OSHA representatives. Keep in mind that there are many exemplary programs both in other Federal agencies and in many private firms. Explanations of hearing conservation and noise control concepts will best be found in texts other than that by Barr and Miller.

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APPLIED TIME SERIES ANALYSIS VOLUME 1. BASIC TECHNIQUES

R.K. Otnes and L. Enochson
John Wiley & Sons, New York, NY
1978, $33.50

Time series analysis is used in many disciplines, from economics to physics, mathematics, statistics, and engineering. The engineer or scientist who deals directly with data analysis must know the terms utilized. To solve time series data problems, the analyst relies upon knowledge of stochastic processes. The authors write "the emphases will be on software as opposed to hardware. Fortran or other high level programming language as opposed to machine lan-

guage, floating point as opposed to fixed point calculations, and flexibility as opposed to optimality." The authors stress applications using digital methods. The book is an updated and expanded version of an earlier book entitled, Digital Time Series Analysis.

Chapter I briefly discusses the Fourier transform, linear systems, effect of finite sample, length of data, Nyquist frequency, Z transform, and discrete Fourier transforms of definite length.

Chapter II delves into various probability and statistical concepts; e.g., normal distribution, correlation and regression, auto (power) spectral density (psd), the probability histogram, and the probability density function.

Chapter III introduces procedural aspects of data collection and processing. Removal of a trend and/or wild point, both of which would cause false data analysis, is described.

Chapter IV is concerned with digital filter design. The basic first-order, second-order, higher-order, Butterworth, tangent and recursive plus filter approximation techniques are included. Although the information is important, the reviewer feels that it should have been placed in an appendix because it is directly concerned with the type of hardware.

Chapter V on the practical aspects of digital filters covers noise, distortion, and instability of data when it is analyzed by a digital machine. Another point worth considering is the deterioration of data analysis due to degeneration of filter performance. The chapter concludes with a procedure for discarding unwanted or redundant information that could have an impact on the analysis of data. Use of the proper filter alleviates the deterioration of true data.

Chapter VI considers Fourier transform theory -- the heart of time series analysis and very efficient when properly used in computation. At one time, the discrete fourier transform (DFT) was predominant in digital analysis of data; it has now been supplanted by the fast fourier transform (FFT), which is more versatile and faster. The authors provide a brief but lucid background description of FFT and include FFT computer programs. This chapter also considers ways for analyzing both stationary random and narrow-band noise.

Chapter VII on time series analysis describes recognized correlation functions and covariance in time series analysis. The advent of FFT has made economical the indirect determination of the covariance function. Convolution, which is fundamental to time series analysis, is a direct application of digital filters. Moving averages, which are employed in smoothing data, are considered. The chapter concludes with the aliasing effect (Nyquist frequency) and its direct bearing upon proper data analysis.

Chapter VIII has to do with the heart of stochastic analysis; i.e., power spectral density (psd) and cross spectral density (csd). The most widely used methods for computing psd are Blackman-Tukey (DFT), FFT, and the bandpass filter. Resolution bandwidth (Be), record length (P), number of data points (N), and number of averaged elementary components (m) are important. Be and P play very important roles in data analysis by FFT. Another important aspect is proper resolution of data to prevent smearing or bias. The chapter concludes with means for minimizing leakage. Power leaking out of the spectral bandwidth causes distortion of data; prevention of leakage requires proper use of data windows -- such as the Hanning window or Goodman-Enochson-Otnes window. The authors provide good illustrations to describe ensemble averaging and frequency averaging.

The last chapter is concerned with transfer and coherence functions, including simple and more complex coherence; e.g., multiple and partial coherence. Other topics include confidence limits for coherence and the confidence band. Matrix methods are used to compute simple and complex transfer functions and are illustrated by examples. Multiple system inputs are applied to plotting the transfer functions. The reviewer was disappointed that the authors failed to describe in detail the important aspects of multiple and partial coherence concepts. The book also contains a number of tested computer programs directly applicable to times series analysis.

The authors are to be commended for bridging the gap between digital signal processing and time series analysis as used by the statistician. Higher mathematics is kept to a minimum; for more detailed study, the reader is referred to more advanced texts. The reviewer looks forward to Volume II, which will contain advanced work in pre-whitening, autoregressive moving average, and maximum entropy

spectral analysis (MESA). The book will be of interest to individuals directly concerned with the random data inherent in time series analysis.

H. Saunders
General Electric Co.
Schenectady, New York 12345

SHORT COURSES

SEPTEMBER

DYNAMICS OF SEA-BASED STRUCTURES

Dates: September 14-18, 1981

Place: Corvallis, Oregon

Objective: The fundamentals of structural dynamic analysis and of wave load prediction will be reviewed and used to develop methods to describe the dynamic behavior of sea-based structures. The session topics will include: introduction and background material; types and behavior of sea-based structres; review of fluid mechanics; linear wave theory; real waves: wave flume demonstration; single degree-of-freedom (DOF) natural vibrations; single degree-of-freedom (DOF) forced vibrations; wave forces on small members; ocean interactions of single DOF systems; multiple DOF formulations and matrices; multiple DOF natural vibrations; wave forces on large members; interaction effects; ocean examples of multiple DOF systems; modal synthesis of forced vibrations of large systems Direct integration methods; numerical methods; random waves and forces; computer simulations for large ocean structures; random vibrations of structures; spectral analysis of wave-structure interaction; nonlinear interactions; current research topics; and examples of structures in real sea conditions.

Contact: Martin Northcraft, Short Course Coordinator, Dept. of Civil Engineering, Oregon State University, Corvallis, OR 97331 - (503) 754-3494.

10TH ADVANCED NOISE AND VIBRATION COURSE

Dates: September 14-18, 1981

Place: Southampton, England

Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures, including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise, which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise and environmental noise and planning.

Contact: Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH, England - (0703) 559122 X 2310/752, Telex 47661.

BASIC INSTRUMENTATION SEMINAR

Dates: September 15-17, 1981

Place: New Orleans, Louisiana

Dates: October 20-22, 1981

Place: Houston, Texas

Dates: October 27-29, 1981

Place: Pittsburgh, Pennsylvania

Objective: This course is designed for maintenance technicians, instrument engineers, and operations personnel - those individuals responsible for installation and proper operation of continuous monitoring systems. An in-depth examination of probe installation techniques and monitoring systems including types, functions, and calibration procedures is provided. Also presented is an overview of some of the instrumentation used to acquire data for vibration analysis, including oscilloscopes, cameras, and specialized filter instruments.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

MACHINERY DATA ACQUISITION

Dates: September 28 - October 2, 1981
December 7-11, 1981

Place: Carson City, Nevada

Objective: This seminar is designed for people whose function is to acquire machinery data for dynamic analysis, using specialized instrumentation, and/or that person responsible for interpreting and analyzing

the data for the purpose of corrective action on machines. Topics include measurement and analysis parameters, basic instrumentation review, data collection and reduction techniques, fundamental rotor behavior, explanation and symptoms of common machinery malfunctions, including demonstrations and case histories. The week also includes a lab workshop day with hands-on operation of the instrumentation and demonstration units by the participants.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

OCTOBER

UNDERWATER ACOUSTICS

Dates: October 5-9, 1981
Place: University Park, Pennsylvania
Objective: This course is designed to introduce the basic principles and concepts of underwater acoustics to those new to the field as well as to serve as a refresher for those who need to become acquainted with recent advances. Topics presented include underwater sound propagation, sonar concepts, ambient noise and reverberation considerations, transducer technology, nonlinear acoustics and parametric arrays, target physics, and radiated and self noise due to turbulent flows and cavitation.

Contact: Alan D. Stuart, Course Chairman, The Applied Research Laboratory, The Pennsylvania State University, P.O. Box 30, State College, PA 16801 - (814) 865-1397.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: October 5-9, 1981
Place: Bournemouth, England
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

DESIGN OF FIXED OFFSHORE PLATFORMS

Dates: October 5-16, 1981
April 5-16, 1982
Place: Austin, Texas
Objective: This course is dedicated to the professional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas at Austin, Austin, Texas 78712 - (512) 471-3506.

MACHINERY VIBRATION ANALYSIS

Dates: October 6-9, 1981
Place: Houston, Texas
Dates: November 3-6, 1981
Place: Atlanta, Georgia
Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow speed paper rolls.

Contact: Dr. Ronald L. Eshleman, The Vibration Institute, 101 West 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

ENGINEERING APPLICATIONS OF CORRELATION AND SPECTRAL ANALYSIS

Dates: October 12-15, 1981
Place: Chicago, Illinois
Dates: November 2-5, 1981
Place: Washington, D.C.

Objective: This four-day short course covers important engineering applications of correlation and spectral analysis relative to acoustics, mechanical vibrations, system identification and fluid dynamics problems in the aerospace, automotive, industrial noise control, civil engineering and oceanographic fields. Applications include identification of system properties and response effects, estimation of time delays and propagation velocities, determination of energy sources, and utilization of practical statistical error formulas to evaluate results. Comprehensive methods are explained to solve single input/single output problems, single input/multiple output problems and multiple input/multiple output problems, where arbitrary correlation and coherence functions (ordinary, partial, multiple) can exist among the records. Participants will be able to have questions answered that are of concern to their own individual projects.

Contact: Continuing Education Institute, 10889 Wilshire Blvd., Suite 1030, Los Angeles, CA 90024 - (213) 824-9545 or Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044 - (301) 596-0111.

VIBRATION CONTROL

Dates: October 12-16, 1981
Place: University Park, Pennsylvania

Objective: The seminar emphasizes principles, general approaches and new developments, with the aim of providing participants with efficient tools for dealing with their own practical vibration problems.

Contact: Debra A. Noyes, 410 Keller Conference Center, University Park, PA 16802 - (814) 865-8820, TWX No: 510-670-3532.

RELIABILITY ENGINEERING, TESTING AND MAINTAINABILITY ENGINEERING

Dates: October 19-23, 1981
Place: Los Angeles, California

Objective: After completing this course, participants should be able to calculate the failure rates of components and products; construct their Reliability Bathtub curves; determine the early, chance and wearout reliability of components; determine from data the parameters of the times-to-failure distributions of components and products analytically and by probability paper plotting; apply the Chi-Squared and Kolmogorov-Smirnov goodness-of-fit tests; identify the most appropriate distribution to use and couple it with the phenomenological aspects of the underlying life distribution; determine the reliability of systems of any complexity, including series, parallel, standby, load-sharing, multimode function and switching; determine the confidence limits on the reliability for the exponential, normal, Weibull and binomial cases; apply sequential testing and draw up such test plans for the exponential and binomial cases; determine the times-to-restore distribution of equipments when they fail; determine the maintainability of the equipment for a desired maintenance time; combine the reliability and maintainability indices into the overall availability of these equipments; and acquire the skills of applying reliability engineering, reliability testing and maintainability engineering concepts to components, equipment and systems.

Contact: Robert Rector, Assistant Director, Short Courses, UCLA, 6266 Boelter Hall, Los Angeles, CA 90024 - (213) 825-3496, 825-1295, or 825-3344.

VIBRATION THEORY AND APPLICATIONS TO DESIGN

Dates: October 27-29, 1981
Place: Southampton, England

Objective: Topics to be covered in this course include: dynamic properties of structures; harmonically forced vibration - resonance, damping, dynamic magnification factors; transient vibration - impulse response, effect of pulse shape, shock spectra; transmission of vibration; natural frequencies and mode shapes of structural elements - use of data sheets and handbooks; random vibration - spectral density of response, mean square response, fatigue life estimates; and statistical energy analysis - theory and applications.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH - (0703) 559122, Ext. 2310.

NOVEMBER

19TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 9-13, 1981

Place: Tucson, Arizona

Objective: Emphasis will be on reliability engineering theory and practice; mechanical reliability prediction; reliability testing and demonstration, reliability data sources, maintainability engineering, and life cycle costing; product liability; reliability and maintainability management, and life-cycle costing. The Institute is designed for engineers and managers in reliability, product assurance, QC, manufacturing, sales and service; other engineers, statisticians, government and industry representatives, plus college and university teachers.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Dept., Building 16, The University of Arizona, Tucson, AZ 85721 - (602) 626-2495, 626-3901, or 626-3054.

COMPUTER TECHNIQUES FOR DYNAMIC STRUCTURAL DESIGN

Dates: November 24-26, 1981

Place: Southampton, England

Objective: Topics include: introduction to approximate methods of structural vibration analysis: Rayleigh-Ritz and finite element methods; vibration of frame type structures; finite element modeling of structures; data preparation for finite element programs; vibration of plate structures; vibration of shell structures; assessing the accuracy of elements; computer graphics as an aid to structural design; choice of solution techniques: eigenvalue problems, reduction methods; substructuring; transient response.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton S09 5NH - (0703) 559122, Ext. 2310.

FEBRUARY

VIBRATION TESTING AND SIGNAL ANALYSIS

Dates: February 16-18, 1982

Place: Southampton, England

Objective: Topics include: types of testing: introduction to the various types of signal-linear system theory, etc. (i) testing with applied excitation - techniques - steady state, slow sweep, transient, random, (ii) response analysis (only) - system in motion due to natural excitation; instrumentation and signal conditioning - effects of attachments on system characteristics; instrumentation system characteristics; limitations, e.g. bandwidth, integration, analogue filtering, etc.; signal processing; and specification testing.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH - (0703) 559122, Ext. 2310.

BALANCING OF ROTATING MACHINERY

Dates: February 23-25, 1982

Place: Houston, Texas

Objective: The seminar will emphasize the practical aspects of balancing in the shop and in the field. The instrumentation, techniques, and equipment pertinent to balancing will be elaborated with case histories. Demonstrations of techniques with appropriate instrumentation and equipment are scheduled. Specific topics include: basic balancing techniques (one- and two-plane), field balancing, balancing without phase measurement, balancing machines, use of programmable calculators, balancing sensitivity, flexible rotor balancing, and effect of residual shaft bow on unbalance.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

SHOCK AND VIBRATION CONTROL

Dates: March 16-18, 1982

Place: Southampton, England

Objective: Topics include: introduction - structural parameters and their role in vibration control; dynamic properties of structural materials - damping materials and their properties, application of damping treatments to structures, fibre reinforced plastics, fatigue; mobility methods - concepts, system coupling, application to the isolation problem, approximate methods; vibration transmission through structures - path identification - classical, cross correlation, etc., power flow - mechanisms, use of statistical energy methods, acoustic radiation, radiation

efficiency; shock - impacts in machines - effects of structural parameters on acoustic radiation, isolation - machinery installations, the transient environment - packaging and packaging materials.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH - (0703) 559122, Ext. 2310.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

OCEAN STRUCTURAL DYNAMICS SYMPOSIUM '82
September 8-10, 1982
Corvallis, Oregon

The Ocean Structural Dynamics Symposium '82 will be held September 8-10, 1982 at Oregon State University, Corvallis, Oregon. The objective of this symposium is to bring together researchers and engineers to review and discuss the current state of technology in the dynamic analysis and design of offshore structure, mooring and foundation systems.

Topics for the eight technical sessions are:

- Wind, wave, current, earthquake, impact loads
- Drift and mooring forces
- Stochastic and deterministic wave analysis
- Analytical and numerical prediction methods
- Experimental and prototype studies
- Floating and semisubmersible structures
- Tension and catenary leg platforms
- Buoys and drogues
- Multi-body interactions
- Anchor deployment and loading
- Riser and pipeline analysis and design
- Fluid-structure-foundation interaction
- Wave power analysis

For further information, contact: Dr. John Leonard, OSDS '82 Chairman, Dept. of Civil Engineering, Oregon State University, Corvallis, OR 97331 - (503) 754-3481.

SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION SYMPOSIUM
June 7-11, 1982
Washington, D.C.

The 6th IFAC Symposium on System Identification and Parameter Estimation will be held June 7-11, 1982 at the Rosslyn Westpark Hotel in Washington, D.C. It follows the tradition of previous symposia in bringing together distinguished scientists in the area of System Identification from all over the world under the auspices of IFAC and the sponsorship of the Control Systems Society of the Institute for Electrical and Electronic Engineers.

The symposium will host a variety of invited and contributed papers covering all aspects of system identification and modeling, as well as of parameter and state estimation and their relation to control. Particular emphasis will be placed on the use of identification and estimation methods in the study of process optimization and control, adaptive learning and robotic systems, biomedical and health care delivery systems, large-scale societal and engineering systems, aero and space vehicle design, seismic data processing, and speech and image analysis. Hardware and software implementation of identification and estimation techniques by the use of microprocessors is also of interest to the symposium. The meeting will be highlighted by prominent keynote speakers and will include various discussion sessions and tutorial workshops.

The meeting is scheduled in conjunction with the 1982 American Control Conference to be held June 14-16, 1982 at the Sheraton National Hotel, Arlington, Virginia. Due to the short distance between the two conference sites and the scientific affinity of the two meetings, it is expected that a number of attendees will find this a convenient opportunity to attend both meetings.

For further information, contact: Professor George A. Bekey, Chairman, National Organizing Committee, Dept. of Electrical Engineering - Systems, University of Southern California, Los Angeles, CA 90007 - (213) 743-7811.

NOISE CONTROL PAPERS PRESENTED AT NOISE-CON '81

Papers presented at NOISE-CON '81 dealt with machinery noise, noise source identification, noise

reduction by barriers and enclosures and applications of damping material. Particular emphasis was placed on machinery noise in the metal fabricating industry, punch press noise, noise control in the textile and fiber industries, woodworking industry noise control and noise control in the tobacco and packaging industries.

The papers are available in the form of a 488-page book of Conference Proceedings. The price of the volume is $42.00 with an additional charge of $12.50 if the volume is to be mailed overseas by Air Mail.

For further information, contact: Noise-Con '81, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603.

28TH INTERNATIONAL INSTRUMENTATION SYMPOSIUM
May 3-6, 1982
Las Vegas, Nevada

The 28th International Instrumentation Symposium returns to Las Vegas in the ninth edition of annual symposia sponsored jointly by the Aerospace Industries and Test Measurement Divisions of the Instrument Society of America. These symposia have become recognized as the outstanding forum for discussion of new and innovative instrumentation techniques, development, and applications.

Topics of the symposium include:

- Measurements

  Pressure, Flow, Strain, Force, Motion, Shock and vibration, Thermal

- Data Acquisition/Analysis/Control

  Data acquisition techniques, Data processing and analysis, Real time control, Real time display, Telemetry systems/methods, Microcomputer applications, Minicomputer applications

- Instrument Applications

  Flight test, Wind tunnel test, Aerospace, Reentry vehicle testing, Energy related instrumentation and control, Nuclear, Transportation industry, Machinery and rotating equipment, Special test facilities, Avionics instrumentation and testing, Blast environment instrumentation

- Special/Advanced Technology

  Two-phase flow measurements, NDT and acoustic emission, Electro-optical instrumentation

For further information, contact: Marvin McKee, Calspan, PWT MS600, Arnold Air Force Station, Tennessee 37389.

INFORMATION RESOURCES

THE RELIABILITY ANALYSIS CENTER (RAC)

Mission

The Reliability Analysis Center is a Department of Defense-sponsored Information Analysis Center located at the Rome Air Development Center, Griffiss Air Force Base, NY. RAC's mission is to collect, analyze, format and disseminate reliability information on microcircuit, discrete semiconductor, and certain electrical/electromechanical components and the equipment/systems in which the components are used. The information is disseminated in the form of reliability data compilations, handbooks, databooks, state-of-the-art studies, literature searches, training courses, workshops, and unbiased user request responses.

Resources

The resources of the RAC include its staff of engineers, technicians, computer operators, and support personnel, many of whom have worked for government or industry in the electronics reliability/maintainability field. Many staff members are involved in industrial or professional committees and in technical symposia. Its proximity to the RADC allows frequent dialogue with Air Force reliability and maintainability specialists.

The staff carries on an extensive data collection effort throughout industry and government from producers and users of electronic devices and equipment. The major source of reliability data is from military programs, where requirements are placed on the contractor to collect reliability data during all phases of equipment/system production, and from the various military data collection systems on fielded systems. Through numerous contacts RAC also solicits information from the private sector; much information comes from companies seeking unbiased evaluation of their products' reliability in the light of government requirements. Although unpublished data is the major data resource, the RAC library contains published data as well in the forms of R&D reports, technical society and trade journals, conference and symposia proceedings, etc., providing the staff with the most current published sources at a growth rate of over 600 per year.

The computerized data system is stored on RADC's H6180 computer complex and is expanding by over 12,000 records per year. Data files and processing capabilities are implemented with the Honeywell MDQS data management system, allowing studies on R&M and cost data from systems/equipment down to the lowest nomenclatured item through the entire life cycle.

With the data collected, filed and indexed, the RAC staff utilizes the information in several different forms. Individually tailored, unbiased user inquiry responses to help determine, specify and implement appropriate R&M procedures are answered either by telephone or by written report. Also, state-of-the-art studies on a variety of topics are conducted and published as Technical Reliability Studies. Approximately on a yearly cycle the RAC databooks are rewritten and updated to reflect current information in the database. The databooks represent reliability data on Microcircuit Devices, Discrete Semi-conductors, Nonelectronic Parts, and Electronic Equipment Reliability and Maintainability. Each of these publications contains analyzed summary tables, charts, graphs, and detailed screening, burn-in environmental and field failure rate data. The microcircuit data books contain information on digital, linear, interface, and LSI microprocessor and memory devices. Discrete semiconductor documents highlight selected state-of-the-art technologies such as microwave devices, optoelectronic devices, LEDs and solid state relays. The Nonelectronic Parts publications discuss selected electrical and electromechanical components such as switches, mechanical relays, connectors, motors, and blowers, etc., that are especially vulnerable to reliability problems.

In addition to databooks, the RAC has developed a training course on design reliability based on the RAC publication <u>Reliability Design Handbook</u> to

guide design engineers and managers in proper and effective design and management techniques to ensure production of reliable equipment.

The RAC Newsletter is a gratis quarterly publication designed to inform the electronics community of new publications, findings, and events; at present, the newsletter reaches 15,000 readers.

Services

In order to recover some of its operating costs, the RAC is directed by the DoD to make its services available to qualified members of the electronics community for a fee, determined by the services desired. Databooks are available directly from the RAC as well as NTIS. For information concerning services and publications, contact Dr. Charles E. Ehrenfried, Technical Director, Reliability Analysis Center, RADC/RBRAC, Griffiss Air Force Base, NY 13441 or (315) 330-4151 or Autovon 587-4151.

ADVANCE PROGRAM

52ND SHOCK AND VIBRATION SYMPOSIUM

October 27-29, 1981

New Orleans, Louisiana

Defense Nuclear Agency and U.S. Army Waterways Experiment Station
will be your host for this Symposium

THE SHOCK AND VIBRATION
INFORMATION CENTER

GENERAL INFORMATION

CONFERENCE LOCATION: Registration, Information, and Unclassified Technical Sessions are at the Monteleone Hotel, New Orleans, LA. Classified Sessions will be held at the NASA Michoud Assembly Facility. There is a separate program for the classified sessions.

Travel orders for U.S. Government employees should indicate the Monteleone Hotel as the main conference location.

REGISTRATION: All registrants must complete the UNCLASSIFIED Registration Card enclosed with this program before they may attend the technical sessions at the Monteleone Hote. Registrants qualified to attend the CLASSIFIED SESSIONS must follow instructions presented in the program for those sessions. ADVANCE REGISTRATION BY MAIL IS STRONGLY RECOMMENDED. Simply complete and return the UNCLASSIFIED Registration Card to the address given thereon.

Fee: Registration fee covers the cost of the proceedings of the 52nd Shock and Vibration Symposium. There is no fee for SVIC Annual Subscribers* and for participants. Since the registration fee covers only the cost of the proceedings, there will be no reduced fee for part time attendance. The schedule of fees is as follows:

Subscriber Registration (for employees of
SVIC Annual Subscribers . . . . .No Fee
Participant Registration (Authors,
Speakers, Chairman, Cochairman). . . . . . .No Fee
General Registration (All others)
(Payable to Disbursing Officer, NRL) . . . $140.00

On-Site Registration: Pre-registrants may obtain their badges or last minute unclassified registration may be accomplished at the following times:

Monteleone Hotel
Monday, October 26 . . . . . 7:00 p.m. - 8:00 p.m.
Tuesday, October 27 . . . . . 7:30 a.m. - 4:00 p.m.
Wednesday, October 28 . . . 8:00 a.m. - 4:00 p.m.
Thursday, October 29 . . . . 8:00 a.m. - 2:00 p.m.

INFORMATION: An information and message center will be located in the registration area. The phone number in the registration area is (504) 523-3341. Ask for the Shock and Vibration Symposium. Telephone messages and special notices will be posted near the registration desk. All participants should check regularly for messages or timely announcements. Participants will not be paged in the sessions.

OUTSIDE ACTIVITIES: A special planned program of outside activities is available to spouses. (Details are in the enclosed brochure.) Since these events can be held only if sufficient interest is shown, it is IMPORTANT THAT ADVANCE REGISTRATION of intent to participate be received. A form for this purpose is included in the brochure.

SPECIAL TOUR: It is likely that a special tour of technical interest will be planned for the morning of Friday, October 30, 1981 for those who wish to stay over. Details will be available in the final program.

LODGING: A block of rooms has been reserved at the Monteleone Hotel for those attending the Symposium. All reservations may be made by forwarding the enclosed Hotel Reservation Card directly to the Monteleone Hotel. It is recommended that hotel *reservations be made well in advance of the meeting* and, in no case later than 5 October 1981.

COMMITTEE MEETINGS: Space is available to schedule meetings for special committees and working groups at the Symposium. To reserve space contact SVIC. A schedule of special meetings will be printed in the final program.

SVIC STAFF:

Mr. Henry C. Pusey, Director
Mr. Rudolph H. Volin
Dr. J. Gordan Showalter
Mrs. Elizabeth McLaughlin (Secretary)

Shock and Vibration Information Center
Naval Research Laboratory, Code 5804
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Autovon: 297-2220

* ***A SVIC Annual Subscriber is an organization that has purchased the SVIC Annual Subscription Service Package for Fiscal Year 1982 (1 October 1981 - 30 September 1982).***

PUBLICATIONS

PROCEEDINGS: THE SUMMARIES OF PRESENTED PAPERS will be published in advance. These summaries are longer than the usual abstract and contain enough detail to evaluate their usefulness to you as an individual. By receiving these in advance, you may more effectively choose the papers you wish to hear. IN ORDER TO RECEIVE THE SUMMARIES IN ADVANCE BE SURE YOUR REGISTRATION IS IN OUR HANDS BY 2 October 1981.

SHOCK AND VIBRATION BULLETIN NO. 52: Papers presented at the 52nd Symposium will, at the author's request, be reviewed and published in the Bulletin after approval by two reviewers. The discussion following these papers will be edited and published with the respective papers. Registrants who have paid the registration fee or have satisfied the registration requirements will receive a copy of the Bulletin. Additional sets of the 52nd Bulletin will be sent to Annual Subscribers. Others may purchase the Bulletin from the Shock and Vibration Information Center. The price is $140.00 for each set delivered in the United States.

OTHER PUBLICATIONS: Sample copies of current publications of the Shock and Vibration Information Center may be examined at the registration area. Order blanks are available for those wishing to use them.

52ND SYMPOSIUM PROGRAM COMMITTEE

Lt. Col. Dwayne Piepenburg
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Alexandria, VA 22310

Mr. Charles Fridinger
Naval Surface Weapons Center
White Oak, Silver Spring, MD 20910

Mr. Don McCutchen
NASA Johnson Space Center
Houston, TX 77058

Mr. Tommie Dobson
6585 Test Group
Holloman AFB, NM 88330

Mr. James Daniel
U.S. Army Missile Command
Redstone Arsenal, AL 35898

OPENING SESSION

Tuesday, October 27 **9:00 a.m.**

Chairman: Dr. Eugene Sevin, Defense Nuclear Agency, Washington, DC

Cochairman: Mr. Henry C. Pusey, Shock and Vibration Information Center, Naval Research Laboratory, Washington, DC

Welcome: DNA Representative

Keynote Address: Dr. Marvin Atkins, Director, Offensive and Space Systems, OUSDRE (S455), Department of Defense, Washington, DC

Invited Speakers: Dr. Charles Davidson, Technical Director, U.S. Army Nuclear and Chemical Agency, Springfield, VA – Subject: "Equipment Survivability on the Integrated Battlefield".

Captain Donald Alderson, USN, Acting Chief, Tactical Nuclear Weapons Project Office (PM-23), Department of the Navy, Washington, DC -- Subject: "Naval Operations in a Nuclear Environment".

Dr. Henry F. Cooper, Deputy for Strategic and Space Systems, Assistant Secretary of the Air Force (Research, Development and Logistics), Washington, DC -- Subject: "Survivability Requirements for Future Air Force Strategic Systems".

Dr. Edward Conrad, Deputy Director (Science and Technology), Defense Nuclear Agency, Washington, DC – Subject: "Nuclear Hardness Validation Testing".

SPACE SHUTTLE FILM

SESSION 1A

Tuesday, October 27 **1:30 p.m.**

ROTOR DYNAMICS AND MACHINERY VIBRATION

Chairman: Mr. Samuel Feldman, NKF Engineering Associates, Inc., Vienna, VA

Cochairman: Mr. Paul H. Maedel, Jr., Westinghouse Electric Corporation, Philadelphia, PA

1. An Overview of Flexible Rotor Balancing Technology -- N.F. RIEGER, Stress Technology, Inc., Rochester, NY
2. Spin Test Vibrations of Pendulously Supported Disc/Cylinder Rotors – F.H. WOLFF and A.J. MOLNAR, Westinghouse Research and Development Center, Pittsburgh, PA
3. Modal Analysis Evaluation of a Failed Impulse Stage of a High Pressure Steam Turbine -- A.L. MOFFA and R.H. LEON, Franklin Research Center, Philadelphia, PA
4. The Effects of Seals on Rotor Systems -- D.P. FLEMING, NASA Lewis Research Center, Cleveland, OH

BREAK

5. Machinery Vibration Evaluation Techniques – R.L. ESHLEMAN, Vibration Institute, Clarendon Hills, IL
6. Contribution to the Dynamic Behaviour of Flexible Mechanisms – J.D. HAGOPIAN, E.I. IMAM and M. LALANNE, Institute National des Sciences Appliquees, Villeurbanne, France
7. Self-Excited Vibration of a Nonlinear System with Random Parameters -- R.A. IBRAHIM, Texas Tech University, Lubbock, TX
8. Shaft Vibration Measurement and Analysis Techniques D. BENTLY, Bently Nevada Corp., Minden, NV

SESSION 1B

Tuesday, October 27 **1:30 p.m.**

ENVIRONMENTAL TESTING AND SIMULATION

Chairman: Mr. David O. Smallwood, Sandia National Laboratories, Albuquerque, NM

Cochairman: Mr. Leo Ingram, Waterways Experiment Station, Vicksburg, MS

1. Digital Control of a Shaker to a Specified Shock Spectrum – J.F. UNRUH, Southwest Research Institute, San Antonio, TX
2. Gunfire Vibration Simulation on a Digital Vibration Control System – J.M. CIES, Hewlett Packard, Paramus, NJ
3. Measurement of All Components of Strain by a 3-D Fiber Optic Strain Gage -- S. EDELMAN and C.M. DAVIS, JR., Dynamic Systems, Inc., McLean, VA
4. Hysteretic Registration of the SE Soil Stress Gage -- C.R. WELCH and J.K. INGRAM, Waterways Experiment Station, Vicksburg, MS
5. Cable Protection for Ground Shock Instrumentation in Severe Environments – Results of an Evaluation Test -- C.R. WELCH, Waterways Experiment Station, Vicksburg, MS

BREAK

6. Structural Response of HEPA Filters to Shock Waves – P.R. SMITH, New Mexico State University, Las Cruces, NM and W.S. GREGORY, Los Alamos National Laboratory, Los Alamos, NM

7. A Technique Combining Heating and Impact for Testing Reentry Vehicle Impact Fuzes at High Velocities -- R.A. BENHAM, Sandia National Laboratories, Albuquerque, NM

8. An Explosively Driven Launcher Useful for Fragment Impact Studies at 1800 to 3800 M/S -- F. MATHEWS, Sandia National Laboratories, Albuquerque, NM

9. Use of a Dropped-Weight to Simulate a Nuclear Surface Burst – C.R. WELCH and S.A. KIGER, Waterways Experiment Station, Vicksburg, MS

10. Analysis and Testing of a Non-Linear Missile and Canister System – C. McKINNIS, A. DEERHAKE, and R. BENSON, General Dynamics/Convair, San Diego, CA

SESSION 1C

Tuesday, October 27 **1:30 p.m.**

SPACE SHUTTLE LOADS AND DYNAMICS

Chairman: Mr. Donald C. Wade, NASA Johnson Space Center, Houston, TX

Cochairman: Dr. Vernon Neubert, Pennsylvania State University, University Park, PA

1. Introduction

2. The Space Shuttle Structural Dynamic Model Verification Program – C.T. MODLIN, JR. and G.A. ZUPP, JR., NASA Johnson Space Center, Houston, TX

3. Space Shuttle Structural Design Load Procedures – A.C. MACKEY, NASA Johnson Space Center, Houston, TX

4. Space Shuttle Pogo Verification Program – G.A. ZUPP, JR. and R.T. ANDERSON, NASA Johnson Space Center, Houston, TX and S.S. LEE, Rockwell-Downey, Downey, CA

5. Space Shuttle Main Engine (SSME) Pogo Testing and Results – R. JEWELL, J. JONES and J. FENWICK – NASA Marshall Space Flight Center, Huntsville, AL

BREAK

6. Orbiter Landing Loads Math Model Description and Correlation with ALT Data – D.A. HAMILTON, J.A. SCHLIESING and G.A. ZUPP, JR., NASA Johnson Space Center, Houston, TX

7. Space Shuttle Solid Rocket Booster Water Entry Cavity Collapse Loads -- R.T. KEEFE and E.A. RAWLS, Chrysler Corp., Slidell, LA and D. KROSS, NASA Marshall Space Flight Center, Huntsville, AL

8. Space Shuttle Solid Rocket Booster Reentry and Decelerator System Loads and Dynamics – R. MOOG, Martin Marietta Corp., Denver, CO and D. KROSS, NASA Marshall Space Flight Center, Huntsville, AL

9. Investigation of Side Force Oscillations During Static Firing of the Space Shuttle Solid Rocket Motor – M.A. BEHRING, Thiokol Corp./Wasatch Division, Brigham City, UT

PLENARY A

Wednesday, October 28 **8:30 a.m.**

ELIAS KLEIN MEMORIAL LECTURE

Chairman: Mr. Henry C. Pusey, Shock and Vibration Information Center, Naval Research Laboratory, Washington, DC

Speaker: Dr. H. Norman Abramson, Vice President, Engineering Services, Southwest Research Institute, San Antonio, TX

Subject: **THE CHANGING DIMENSIONS OF QUALIFICATION TESTING**

SESSION 2A

Wednesday, October 28 **9:30 a.m.**

FATIGUE AND RANDOM LOADING

Chairman: Dr. George Morosow, Martin Marietta Corp., Denver, CO

Cochairman: Dr. Grant Gerhart, U.S. Army Tank Automotive R&D Command, Warren, MI

1. Fatigue Life Prediction for Various Random Stress Peak Distributions – R.G. LAMBERT, General Electric Company, Utica, NY

2. Fatigue Life Evaluation, Stochastic Loading, and Modified Life Curves -- M. ELMENOUFY, H. LEIPHOLZ and T. TOPPER, University of Waterloo, Waterloo, Ontario, Canada

3. The Effects of Endurance Limit and Crest Factor on Time to Failure under Random Loading – A.J. CURTIS and S.M. MOITE, Hughes Aircraft Company, Culver City, CA

BREAK

4. Single Point Random Modal Test Technology Application to Failure Detection – W.M. WEST, NASA Johnson Space Center, Houston, TX

5. Forced Vibrations of a Large Damped Mechanical System – D.W. NICHOLSON, Naval Surface Weapons Center, White Oak, Silver Spring, MD

6. Indirect Fourier Transform and Shock Response – C.T. MORROW, Encinitas, CA

SESSION 2B

Wednesday, October 28 **9:30 a.m.**

SPACE SHUTTLE DATA SYSTEMS

Chairman: Mr. Don K. McCutchen, NASA Johnson Space Center, Houston, TX

Cochairman: Mr. Jerome Pearson, Wright Aeronautical Laboratories, Wright Patterson Air Force Base, OH

1. Development of an Automated Processing and Screening System for the Space Shuttle Orbiter Flight Test Data – W.E. PALM, McDonnell Douglas Corp., Houston, TX, D.K. McCUTCHEN, NASA Johnson Space Center, Houston, TX and J.F. BROSE, Lockheed/EMSCO, Houston, TX

2. Development of a Vibroacoustic Database Management and Prediction System for Payloads – F.J. ON, NASA Goddard Space Flight Center, Greenbelt, MD and W. HENRICKS, Lockheed Missiles and Space Company, Sunnyvale, CA

3. Automation of Vibroacoustic Data Bank for Random Vibration Criteria Development – R.C. FEREBEE, NASA Marshall Space Flight Center, Huntsville, AL

BREAK

SPACE SHUTTLE ENVIRONMENTAL TESTING

4. The Development and Verification of Shuttle Orbiter Random Vibration Test Requirements – D.E. NEWBROUGH, Rockwell International Corp., Houston, TX, M.C. COODY, NASA Johnson Space Center, Houston, TX and H.K. PRATT, Rockwell International Corp., Downey, CA

5. Space Shuttle Payload Bay Acoustics – A.C. CHO, Rockwell International Corp., Downey, CA

6. STS-1 Vibroacoustics on the External Tank and Solid Rocket Booster – J.E. McBRIDE and B.E. ERWIN, NASA Marshall Space Flight Center, Huntsville, AL

7. The Shuttle Orbiter DI-19 Multi-Environmental Test Program – H. HIMELBLAU and C.C. SHEPHERD, Rockwell International Corp., Downey, CA, C.E. RUCKER, NASA Langley Research Center, Hampton, VA and D.K. McCUTCHEN, NASA Johnson Space Center, Houston, TX

8. Shuttle Orbiter Acoustic Fatigue Certification Testing – R.A. STEVENS, Rockwell International Corp., Downey, CA

SESSION 3A

Wednesday, October 28 **1:30 p.m.**

CONTROL ISOLATION AND DAMPING

Chairman: Dr. Frederick C. Nelson, Tufts University, Medford, MA

Cochairman: Mr. Ahid Nashif, Anatrol Corporation, Cincinnati, OH

1. Active Vibration Control of Large Flexible Structures – T.T. SOONG and J.C.H. CHANG, State University of New York, Buffalo, NY

2. Force Optimized Recoil Control System – P. TOWNSEND, U.S. Army Armament R&D Command, Dover, NJ, R.F. GARTNER, Honeywell, Inc., Edina, MN and R.J. RADKIEWICZ, U.S. Army Armament R&D Command, Rock Island, IL

3. Semi-Active Suspensions for Military Ground Vehicles under Off-Road Conditions – D.L. MARGOLIS, University of California, Davis, CA

4. Performance Analysis of High-Speed Hydraulic Suspension Systems in Multiple Wheeled Land Transporters – P. WOODS, Martin Marietta Corp., Denver, CO

5. Nonlinear Pneumatic Force Generators for Vibration Control – R.R. GUNTUR and S. SANKAR, Concordia University, Montreal, Quebec, Canada and S.G. KALAMBUR, Electronic Associates Inc., West Long Branch, NJ

6. Reduction of Hydraulic Line Oscillating Pressures Induced by Pump Cavitation – M. BERNSTEIN, P. MARINO, and G. DRUHAK, Grumman Aerospace Corp., Bethpage, NY

BREAK

7. Rubber Isolators for ADATS Missile – C.S. O'HEARNE, Martin Marietta Aerospace, Orlando, FL and J.P. FROTTIER, Oerlikon-Buehrle Werkzeugmaschinenfabrik, Zurich, CH, Switzerland

8. Time and Temperature Effects on Cushions – G.S. MUSTIN, Naval Sea Systems Command, Washington, DC

9. Extraneous Effects in Damping Measurement – R.J. HOOKER, University of Queensland, Queensland, Australia and S. PRASERTSAN, Prince of Songkla University, Hat-Yai, Thailand

10. Damping Material Properties from Sandwich Beam Data Using Sixth Order Theory – L. ROGERS and R.W. GORDON, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH

SESSION 3B

Wednesday, October 28 **1:30 p.m.**

SPACE SHUTTLE THERMAL PROTECTION SYSTEM DYNAMICS

Chairman: Mr. Jess Jones, NASA Marshall Space Flight Center, Huntsville, AL

Cochairman: Mr. James Daniel, U.S. Army Missile Command, Redstone Arsenal, AL

1. Structural Characteristics of the Shuttle Orbiter Ceramics Thermal Protection System – P.A. COOPER, NASA Langley Research Center, Hampton, VA

2. Shuttle Tile Environments and Loads – R.J. MURACA, NASA Langley Research Center, Hampton, VA

3. Dynamic and Static Modeling of the Shuttle Orbiter's Thermal Protection System – R.E. SNYDER, NASA Langley Research Center, Hampton, VA

4. Acoustic Emission Monitoring of Space Shuttle Tiles – W.L. CASTNER, NASA Johnson Space Center, Houston, TX and L.J. CROCKETT and F.E. SUGG, Rockwell International Corp., Downey, CA

5. Buffet Loads on Shuttle Thermal Protection System Tiles – C.F. COE, NASA Ames Research Center, Moffett Field, CA

6. Unsteady Environments and Responses of the Shuttle Combined Loads Orbiter Test (CLOT) - P.H. SCHUETZ, Rockwell International Corp., Downey, CA and L.D. PINSON and H.T. THORNTON, JR., NASA Langley Research Center, Hampton, VA

BREAK

SPACE SHUTTLE MAIN ENGINE DYNAMICS

7. Vibration Maturity of the Space Shuttle Main Engines – E.W. LARSON and E. MOGIL, Rockwell International Corp., Canoga Park, CA

8. Structural Response of the SSME Fuel Feedline to Unsteady Shock Oscillations – E.W. LARSON, G.H. RATEKIN and G.M. O'CONNOR, Rockwell International Corp., Canoga Park, CA

9. Pressure Fluctuations in the Space Shuttle Main Engine – L.A. SCHUTZENHOFER and K.L. SPANYER, NASA Marshall Space Flight Center, Huntsville, AL

PLENARY C

Thursday, October 29 **8:30 a.m.**

Chairman: Mr. Brian Keegan, NASA Goddard Space Flight Center, Greenbelt, MD

Speaker: Dr. Ben K. Wada, Jet Propulsion Laboratory, Pasadena, CA

Subject: **REQUIRED DEVELOPMENTS IN STRUCTURAL DYNAMICS**

SESSION 4A

Thursday, October 29 **9:30 a.m.**

MATHEMATICAL MODELING

Chairman: Dr. Richard Skop, Naval Research Laboratory, Washington, DC

Cochairman: Dr. David I.G. Jones, Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, OH

1. Measurement of Structural Damping Using Random Decrement Technique – J.C.S. YANG and N.G. DAGALAKIS, University of Maryland, College Park, MD and G. EVERSTINE and Y.F. WANG, David W. Taylor Naval Ship R&D Center, Bethesda, MD

2. Damped Structure Design Using Finite Element Analysis – M.F. KLUESENER, University of Dayton Research Institute, Dayton, OH

3. Determination of Mass, Stiffness and Damping Matrices from Measured Complex Modes – S.R. IBRAHIM, Old Dominion University, Norfolk, VA

4. Effect of Joint Properties on the Vibrations of Timoshenko Frames – D.A. FROHRIB, University of Minnesota, Minneapolis, MN and I. YAGHMAI, Ayra-Mehr University of Technology, Tehran, Iran

BREAK

5. Soil-Structure Interaction and Soil Models – J.M. FERRITTO, U.S. Navy Civil Engineering Laboratory, Port Hueneme, CA

6. A Computerised Long Time Stress Wave Analysis of a Large Impact System of Oil and Metal Columns of Varying Geometry and Some Stress Wave Results – W. JOHNSON and S.K. GHOSH, University of Cambridge, Cambridge, England and Y. BAI, University of Peking, Peking, People's Republic of China

7. Finite Elements for Initial Value Problems in Dynamics – T.E. SIMKINS, U.S. Army Armament R&D Command, Watervliet, NY

SESSION 4B

Thursday, October 29 **9:30 a.m.**

FLIGHT ENVIRONMENTS

Chairman: Mr. John Wafford, Aeronautical Systems Division, Wright Patterson Air Force Base, OH

Cochairman: Mr. Brent Meeker, Pacific Missile Test Center, Point Mugu, CA

1. YC-15 Externally Blown Flap Noise – L.G. PECK, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFC, OH

2. Determination of the Dynamic Environment of the F/FB-111 Tail Pod Assembly – J.M. CHINN and P.G. BOLDS, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH

3. An Evaluation of the A-10's Abilities to Operate on Rapidly Repaired Battle Damaged Surfaces – T.G. GERARDI and D.L. MORRIS, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH

4. Subcritical Flutter Testing Using the Feedback System Approach – C.D. TURNER, North Carolina State University, Raleigh, NC

BREAK

5. SLV 3 Flight Vibration Environment – S.A. PALANISWAMI, G. MUTHURAMAN and P. BALACHANDRAN, Vikram *Sarabhai Space Centre, Trivandrum,* India

6. Shock and Vibration Flight Test Data from the Convair Cruise Missile Programs – E.S. ROSENBAUM and F.L. GLOYNA, General Dynamics/Convair Division, San Diego, CA

7. Test Program to Develop Vibroacoustics Test Criteria for the Galileo Bus – D.L. KERN and C.D. HAYES, Jet Propulsion Laboratory, Pasadena, CA

SESSION 5A

Thursday, October 29 **1:30 p.m.**

STRUCTURAL DYNAMICS

Chairman: Dr. James Richardson, U.S. Army Missile Command, Huntsville, AL

Cochairman: Dr. Nicholas Basdekas, Office of Naval Research, Arlington, VA

1. A Procedure for Designing Overdamped Lumped Parameter Systems – D.J. INMAN, State University of New York at Buffalo, Buffalo, NY and A.N. ANDRY, JR., Michigan State University, East Lansing, MI

2. Inelastic Yield Displacement Spectra – M. PAZ, University of Louisville, Louisville, KY

3. On the Optimal Location of Vibration Supports – W.D. PILKEY and B.P. WANG, University of Virginia, Charlottesville, VA

4. Dynamic Buckling Analysis of Shells of Revolution – P. CRIMI, Avco Systems Division, Wilmington, MA

5. Dynamic Buckling of Pinned Columns – J.M. READY, David Taylor Naval Ship R&D Center, Bethesda, MD

BREAK

6. A Simple Error Measure for the Comparison of Calculated and Measured Transient Response Histories – T.L. GEERS, Lockheed Palo Alto Research Laboratory, Palo Alto, CA

7. Dynamics of Thick Beams of Bimodulus Materials – C.W. BERT and A.D. TRAN, University of Oklahoma, Norman, OK

8. Large Deflection Random Response of Symmetric Laminated Composite Plates: Theoretical Formulation – D.B. PAUL and K.R. WENTZ, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH and C. MEI, Old Dominion University, Norfolk, VA

9. Large Deflection Random Response of Symmetric Laminated Composite Plates: Analytical and Experimental Results Comparison – K.R. WENTZ and D.B. PAUL, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH and C. MEI, Old Dominion University, Norfolk, VA

10. Vibration and Acoustic Radiation from Point Excited Spherical Shells – E.H. WONG, Naval Ocean Systems Center, San Diego, CA and S.I. HAYEK, The Pennsylvania State University, University Park, PA

SESSION 5B

Thursday, October 29 **1:30 p.m.**

SHORT DISCUSSION TOPICS

Chairman: Mr. John Favour, The Boeing Company, Seattle, WA

Cochairman: Mr. Joseph Gaudet, Sanders Associates, Manchester, NH

This session will program papers covering progress reports on current research efforts and unique ideas, hints, and kinks on instrumentation, fixtures, testing, analytical short cuts, and so forth. It is intended to provide a means for up-to-the-minute coverage of research programs and a forum for the discussion of useful ideas and techniques considered too short for a full-blown paper.

Complete titles of short talks will be published in the final program.

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

Rotating Machines
Reciprocating Machines
Power Transmission Systems
Metal Working and Forming
Isolation and Absorption
Electromechanical Systems
Optical Systems
Materials Handling Equipment

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
Off-shore Structures

VEHICLE SYSTEMS

Ground Vehicles
Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

Absorbers and Isolators
Springs
Tires and Wheels
Blades
Bearings
Belts
Gears
Clutches
Couplings
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ABSTRACTS FROM THE CURRENT LITERATURE

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ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 1892, 1893, 1957, 1992, 2009)

81-1800

Torsional Vibrations of a Shaft with Non-Uniform Cross Section

J.M. Pouyet and J.L. Lataillade
Laboratoire de Méchanique Physique, Université de Bordeaux I, 33405 Talence, France, J. Sound Vib., 76 (1), pp 13-22 (May 8, 1981) 7 figs, 6 refs

Key Words: Shafts, Variable cross section, Torsional vibration, Natural frequencies

A solution is presented for the equation governing the propagation of torsional waves in shafts with variable cross sections. The solution permits the treatment of several types of profiles, and in particular to compute the natural frequencies of an axisymmetrical shaft with various kinds of end conditions. Computed frequencies for three kinds of end conditions are compared with those of an equivalent cylindrical shaft, particularly with respect to the dependence on the geometrical characteristics.

81-1801

Insights into Linearized Rotor Dynamics

M.L. Adams and J. Padovan
Dept. of Mech. Engrg., Univ. of Akron, Akron, OH 44325, J. Sound Vib., 76 (1), pp 129-142 (May 8, 1981) 7 figs, 17 refs

Key Words: Rotors, Linear theories

Over the last 20 years, linearized rotor-bearing models have been used in lateral vibration analyses of numerous rotating machines: i.e., prediction of critical speeds, unbalance response, non-synchronous response, and instability threshold speed. Advances in computers and computing techniques over this period have had their effect by expanding the complexity of rotor-bearing systems which can be comprehensively analyzed. However, certain fundamental physical and mathematical properties of these systems have naturally remained unchanged. Some of these fundamental properties have not been given the attention or clarification they deserve, in contrast to the coverage given computing techniques and results. This paper has been written to relate various physical properties of linearized rotor-bearing systems to certain unique mathematical properties they possess.

81-1802

The Effects of Clearance (Looseness) in Drive Shafts on the Dynamic Behavior of Drive Shafts with Flush Mounted Universal Joint Drives (Auswirkungen von Spiel (Lose) in Gelenkwellen auf das dynamische Verhalten von Antriebssträngen mit eingebauten Kreuzgelenkgetrieben)

W. Stühler
Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 61-66 (1980) 10 figs, 6 refs
(In German)

Key Words: Drive shafts, Shafts, Universal joints, Clearance effects

Drive trains with flush mounted universal joint drives, described herein, experience considerable resonance, at large deflection angles of the universal joint drive, at relatively large mass moments of inertia of the drive shaft, and with low damping in the drive train. The critical speeds are lowered by clearances.

81-1803

The Dynamics of Large Windmill Facilities (Zur Dynamik von grossen Windkraftanlagen)

K. Kehl, W. Keim, F. Kiessling, and A. Rippl
Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 113-120 (1980) 13 figs, 3 refs
(In German)

Key Words: Wind mills, Towers, Rotors, Mathematical models

The mathematical basis for a mathematical model of the dynamic behavior of horizontal axis wind mills is outlined. This includes dynamic stability expressions as well as vibration response problems of a system consisting of an elastic tower and an elastically stiff pendulum rotor. The results are obtained for two-bladed rotors (according to Floquet's theory) or for symmetric rotors (with more than two blades).

81-1804

Combined Turbomachinery Rotor and Foundation Vibration Calculation (Gemeinsame Schwingungsberechnung von Rotor und Fundament bei Turbomaschinen)

E. Krämer

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 121-127 (1980) 13 figs

(In German)

Key Words: Rotating machinery, Foundations, Unbalanced mass response

The inclusion of the effects of foundation in the calculation of vibration of turbomachinery greatly increases the amount of calculations. A more efficient method for the determination of vibration response by means of a kinetic stiffness method and a proper selection of substructures is presented. A proposal is made how to condense the numerous results in order to sufficiently represent the smooth running rotor. After a calculation of several cases it can be determined when the foundations need to be taken into consideration.

81-1805

Vibrations of the Laval Rotor-Blade Foundation - Elastic Half Space System Caused by Unbalance (Unwuchterzwungene Schwingungen des Systems Lavalläufer - Blockfundament - elastischer Halbraum)

R. Gasch and W. Sarfeld

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 129-138 (1980) 17 figs, 6 refs

(In German)

Key Words: Rotating machinery, Foundations, Damping, Energy dissipation

The damping of machinery by rotating shafts is investigated. The system consists of a Laval rotor-block foundation - elastic half space. For the rotor an external and internal damping is assumed; the half space is isotropically elastic. For this system the vibrations of the rotor, induced by mass unbalance, are calculated and are represented as a magnification function. The resonance peaks indicate the rotor without internal or external damping, representing a foundation in which the damping of the half space is most effective.

81-1806

Turborotor Parameter Identification: Collocation, Discretization, Parameter Estimation, Gauss-Newton Iteration, Matrix Calculus, Eigenfunctions, Unbalance Response, Experimental Problems (Parameteridentifikation von Turboläufern - Kollokation, Diskretisierung, Parameterschätzung, Gauss-Newton Iteration, Matrizenkalkül, Eigenfunktionen, Unwuchtverlauf, experimentelle Probleme)

V. Schlegel

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 147-154 (1980) 6 figs, 5 refs

(In German)

Key Words: Parameter identification technique, Turbomachinery, Rotors, Turbine components

An identification procedure is described for deriving the matrices of a rotor system. No assumptions for the damping matrix are required and therefore it is not restricted to modal damping. The matrices and the normalized excitation vectors are derived iteratively by means of an estimation procedure.

81-1807

Flexural Vibration of Unbalanced Elastic Rotors at Resonance (Biegeschwingungsverhalten unwuchtiger elastischer Rotoren bei der Resonanzdurchfahrt)

R. Markert

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 155-160 (1980) 10 figs, 8 refs

(In German)

Key Words: Shafts (machine elements), Rotors, Flexible rotors, Resonance pass through

The start up and coast down behavior of an unbalanced flexible, but torsionally stiff, rotor which is accelerated or decelerated by a constant torque is described. The investigation was limited to round shafts in isotropic elastic supports and the only effect taken into consideration is the external damping proportional to the velocity. However, in the investigation the nonlinear coupling term in the torsional equation, which describes the energy exchange between bending and rotation, is included.

81-1808

Experimental Investigation of the Vibrations of a Fluid-filled Rotor under Gyroscopic Effect (Experimentelle Untersuchung des Schwingungsverhaltens eines flüssigkeitsgefüllten Rotors mit Kreiselwirkung)

G. Lichtenberg

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 161-166 (1980) 9 figs, 5 refs
(In German)

Key Words: Rotors, Fluid-induced excitation, Gyroscopic effects

The unstable vibrations of partially fluid-filled rotor above critical speed are induced by the fundamental frequency of the free surface of the fluid. This fundamental frequency was determined experimentally.

81-1809

The Effects of Asymmetry on the Motion of Rotors (Einflusse von Unsymmetrien auf das Bewegungsverhalten von Rotoren)

A. Müller
VDI-Z., 123 (1-2), pp 22-30 (Jan 1981) 14 figs, 9 refs
(In German)

Key Words: Rotors, Damping coefficients, Stiffness coefficients, Asymmetry, Variable material properties

The effect of stiffness and damping asymmetry in elastic bearings and rotor shafts on the motion of rotor-bearing systems is investigated theoretically and experimentally.

81-1810

The Measurement of Aero Gas Turbine Noise

L.R. Bentley
Rolls-Royce Ltd., Derby, UK, Rept. No. 90032, 44 pp (Jan 29, 1980)
N81-14795

Key Words: Turbine engines, Gas turbines, Turbines, Noise measurement

Equipment used in noise certification tests for gas turbine aircraft engines includes: a microphone system, calibrated amplifier and tape recorder; a means of relating aircraft position and the noise; and an apparatus for determining the temperature and humidity conditions in the propagation space for the calculation of atmospheric attenuation. Techniques for obtaining flyover and static test bed measurements are examined and assessed. Future developments are considered with emphasis on the acquisition of digital data.

81-1811

Air/Gas System Dynamics of Fossil Fuel Power Plants. Volume 4: Experimental Vibration and Acoustic Test Data of a 500-MW Unit Interim Report

F.R. Goldschmied, D.N. Wormley, and D. Rowell
Westinghouse Electric Corp. Res. & Development Ctr., Pittsburgh, PA, Rept. No. EPRI-CS-1444-Vol-4, 174 pp (Oct 1980)
N81-16602

Key Words: Fans, Electric power plants, Fossil power plants, Vibration tests, Acoustic tests, Experimental test data

Vibration and acoustic tests were made in a 500 MW oil fired unit, in conjunction to system dynamics pressure data. The test data were taken on one forced draft fan, on one induced draft fan and on the gas recirculation fan. Both cold tests and hot tests were taken for all fans. Identical fans were used for forced draft and for induced draft installation but the acoustic characteristics were different. The test data are presented for future reference without concomitant analysis at this time.

81-1812

Exhaust Noise in Flight: The Role of Acoustic Installation Effects

I.S. Southern
Rolls-Royce Ltd., Derby, UK, Rept. No. PNR-90029, 14 pp (Apr 1980)
N81-14793

Key Words: Engine noise, Sound propagation

The acoustic installation effect on engine exhaust noise due to the presence of a wing or high tailplane is discussed for both the static and flight cases. A simple theoretical model for reflection and edge diffraction using ray theory is introduced and compared with experimental results. The model is used to predict full scale installation effects where, due to the low directivity of engine noise, reflection is dominant and the effect generally less than 3 dB.

81-1813

Effects of Lubricant Viscosity on the Experimental Response of a Three-Mass Flexible Rotor in Two Types of Journal Bearings

R.D. Flack, R.F. Lanes, and P.S. Gambel

Dept. of Mech. and Aerospace Engrg., Univ. of Virginia, Charlottesville, VA 22901, Wear, 67 (2), pp 201-216 (Mar 1981) 15 figs, 1 table, 21 refs

Key Words: Bearings, Rotors, Flexible rotors, Pressure dam bearings, Lubrication

Preloaded three-lobe and pressure dam bearings were tested with a three-mass flexible rotor. The oil viscosity was varied. The resulting changes in the instability threshold were measured and were found to depend markedly on oil viscosity. Data were compared with theoretical stability map predictions.

RECIPROCATING MACHINES

81-1814

Calculation of Nonlinear Periodic Torsional Vibrations of Engines (Zur Berechnung nichtlinearer periodischer Drehschwingungen in Maschinensätzen)

W.D. Pietruszka

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 37-44 (1980) 7 figs, 5 refs

(In German)

Key Words: Asynchronous motors, Reciprocating compressors, Torsional vibration, Electromagnetic properties

Nonlinear equations of motion are derived for the investigation of torsional vibrations of a system consisting of a synchronous motor and a reciprocating compressor, in which the electromagnetic balancing processes are taken into consideration. The results obtained compliment earlier calculations with linear equations of motion.

81-1815

Calculation of the Stationary and Instationary Behavior of a Drive System with Reciprocating Engines (Berechnung des stationaren und instationären Verhaltens von Antriebssystemen mit Kolbenmaschinen)

Ch. Troeder, H. Peeken, and G. Diekhans

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 23-35 (1980) 15 figs, 6 tables, 3 refs

(In German)

Key Words: Reciprocating engines, Torsional vibration

Torsional vibration of systems driven by reciprocating engines are investigated. The behavior of a drive system with a synchronous engine and a three step reciprocating compressor using torsionally elastic and torsionally stiff couplings is studied. As a result of the nonlinear coupling characteristics and periodical mass of inertia moments of the reciprocating drive, the description of the behavior of the system leads to nonlinear differential equations, which can be solved by numerical methods. In this paper the authors explore the extent that general differential equations can be simplified and still give usable results.

81-1816

Torsional Excitation of Drive Units During Intermitted Service of a Combustion Engine (Drehschwingungsbelastung von Antriebsanlagen bei Aussetzerbetrieb des Verbrennungsmotors)

J. Tonndorf

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 11-21 (1980) 18 figs, 1 table, 3 refs

(In German)

Key Words: Reciprocating engines, Torsional vibration

Conditions which can cause damage in drive units operating under seemingly normal conditions are enumerated.

POWER TRANSMISSION SYSTEMS

81-1817

Chain and Belt Drives - A Review

J.N. Fawcett

Dept. of Mech. Engrg., Univ. of Newcastle upon Tyne, Newcastle upon Tyne NE1 7RU, UK, Shock Vib. Dig., 13 (5), pp 5-12 (May 1981) 70 refs

Key Words: Reviews, Belt drives, Chain drives

Surveys of papers relating to the specific problems of chain drives and of belt drives are presented in chronological order. The papers are grouped as follows: the general problem of axially moving materials appropriate to the spans of both chain and belt drives, chain drives, and belt drives.

METAL WORKING AND FORMING

81-1818

Results of an Investigation for the Determination of

Noise of Metal Cutting Machines (Untersuchungsergebnisse zur Beschreibung der Geräuschemission von spanenden Werkzeugmaschinen)
W. Brey
Rheinisch-Westfalische Tech. Hochschule, Aachen, Germany, VDI-Z., 123 (4), pp 105-112 (Feb 1981) 14 figs, 11 refs
(In German)

Key Words: Noise generation, Metal working

Operational conditions for the determination of noise emission of metal cutting machines – which for the most part are given in the standards – are described. Measurements taken during these special operating conditions provide mean values of noise. Further evaluation gives a description of the state of technology. Using statistical methods based on average noise, criteria for judging the machinery under similar conditions are defined.

81-1819
Assessment of Bit Life under Conditions of Rotary-Vibratory Drilling
J.W. David and L.D. Mitchell
Virginia Polytechnic Inst. & State Univ., Blacksburg, VA, ASME Rept. No. 81-Pet-15

Key Words: Drills, Rock drills, Vibratory techniques

This study addresses the topic of the life of the rock bit under conditions of rotary-vibratory drilling as compared to conventional rotary drilling. Conventional rotary drilling systems were analyzed to determine the causes of large dynamic bit loads currently experienced in the drilling industry.

STRUCTURAL SYSTEMS

BRIDGES
(Also see No. 1938)

81-1820
A Review of Traffic Loads and Stresses in Steel Bridges
G.P. Tilly and J.Page
Transport and Road Res. Lab., Crowthorne, UK, Rept. No. TRRL-SUPPLEMENTARY-596, 34 pp (1980)
PB81-135667

Key Words: Reviews, Bridges, Steel, Moving loads, Measurement techniques

This report is a review concerned with traffic loads and the dynamic stresses they cause in highway bridges. Special attention is given to techniques of measurement and to the nature of the load and stress spectra.

BUILDINGS
(Also see No. 1825, 1826, 1921, 1964)

81-1821
Torsional Instability in Structures
R.G. Antonelli, K.J. Meyer, and I.J. Oppenheim
Dept. of Civil Engrg., Carnegie-Mellon Univ., Pittsburgh, PA, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 221-237 (May/June 1981) 12 figs, 12 refs

Key Words: Buildings, Harmonic excitation, Torsional response

Torsional instability under harmonic excitation was detected in structures with cubic softening member stiffness. A variational procedure was introduced to perform the analysis for the general problem formulation. Single-story structures with zero eccentricity were studied first; previous findings were checked and corrected, and the behavior was examined in greater detail. Two-story structures with large eccentricity were also examined, and further regions of torsional instability were detected. Time history analysis was then employed to quantify the behavior of various typical structures.

81-1822
Along-Wind Motion of Multistory Building
J.N. Yang and Y.K. Lin
Dept. of Civil, Mech. and Environmental Engrg., George Washington Univ., Washington, D.C. 20052, ASCE J. Engrg. Mechanics Div., 107 (2), pp 295-307 (Apr 1981) 3 figs, 12 refs

Key Words: Buildings, Multistory buildings, Wind-induced excitation, Random vibration, Transfer matrix method

Treating the wind-excited motion of a multistory building as a random vibration problem, the input-output spectral density relationships are derived using a transfer matrix formulation. In this analysis the motion of the building is restricted to the direction parallel to the average wind flow, the along-wind direction; and the structural response is represented by a displacement variable and a force variable in each story unit. A 40-story building is used as a numerical example.

81-1823

Development of Non-Linear Floor Response Spectra

G. Viti, M. Olivieri, and S. Travi
AMN S.p.A. 1-16121, Genova, Italy, Nucl. Engrg. Des., 64 (1), pp 35-38 (Mar 1981) 8 figs, 1 table, 4 refs

Key Words: *Buildings, Floors, Impact response (mechanical),* Seismic response, Nuclear reactors

A computational scheme for the development of non-linear floor response spectra is presented. Results in the case of an assumed missile impact on a reactor building are shown. Expected reductions, with respect to the linear case, for seismic or missile impact excitations are discussed.

TOWERS

81-1824

Wind-Induced Lock-In Excitation of Tall Structures

K.C.S. Kwok and W.H. Melbourne
School of Civil Engrg., Univ. of Sydney, New South Wales, Sydney 2006, Australia, ASCE J. Struc. Div., 107 (1), pp 57-72 (Jan 1981) 7 figs, 22 refs

Key Words: Towers, Wind-induced excitation, Wind tunnel testing

Circular and square tower models were tested in a boundary layer wind tunnel. At close to the critical reduced velocity *and particularly at low values of structural damping,* displacement dependent lock-in excitation was found to cause large increases in cross-wind displacement response, especially for the circular tower, in a suburban type wind model. Critical cross-wind response amplitudes were determined from the response characteristics. These response amplitudes represent the level of cross-wind response of a structure above which the response cannot be accounted for by the random wake excitation process and that lock-in excitation is significant. A prediction procedure, which consists of a random excitation model and a sinusoidal lock-in excitation model, is described. Cross-wind response predicted by these models agreed well with the measured response.

FOUNDATIONS

(Also see Nos. 1804, 1936)

81-1825

Seismic Response of a Structure Subjected to Rotational Base Excitation

V.N. Shah, W.H. Guilinger, and G.J. Bohm
EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, ID 83401, Nucl. Engrg. Des., 64 (2), pp 195-202 (Apr 1981) 4 figs, 9 refs

Key Words: Nuclear power plants, Foundations, Seismic design, Seismic response, Translational response, Rotational response

A modal superposition method which can perform the seismic analysis of a structure subjected to translational and rotational base excitation is presented. Discussed are two different approaches to derive the equations of motion. In the first approach, the reference axes are fixed in space, while in the second approach, they are rigidly fixed at the base of the structure. For rotational base excitation, it is shown that the application of second approach results in equation of motion with asymmetric, time-dependent coefficient matrix due to presence of the Coriolis acceleration term. The modal superposition method is applied to the seismic analysis of a building subjected to translational and rotational excitation. The displacement results and the computer cost of this analysis are compared with those of using the direct integration method.

81-1826

Separation and Sliding Between Soil and Structure During Strong Ground Motion

K. Toki, T. Sato, and F. Miura
Disaster Prevention Research Inst., Kyoto Univ., Uji, Kyoto, Japan, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 263-277 (May/June 1981) 18 figs, 4 tables, 14 refs

Key Words: Interaction: soil-structures, Ground motion, Finite element technique, Nuclear reactors, Earthquakes

This paper presents an approach to the problem of separation and sliding between soil and structure in the finite element

analysis of dynamic soil-structure interaction problems. Joint elements are arranged along the contact surface between soil and structure and they have a property such that tensile forces are not transmitted between the planes representing structure and soil in the finite element analysis. The dynamic properties governing the sliding are determined by the Mohr-Coulomb failure law determined from the cohesion and the friction angle between soil and structure. The proposed method is applied to a model of a reactor building resting on the free surface of layered ground and a buried foundation structure.

81-1827

An Approximate Method for Soil-Structure Interaction for SH-Waves – The Born Approximation

L.L. Chu, A. Askar, and A.S. Cakmak

Dept. of Civil Engrg., Princeton Univ., Princeton, NJ, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 205-219 (May/June 1981) 12 figs, 19 refs

Key Words: Interaction: soil-structures, Foundations, Elastic waves, Wave diffraction

An approximate method is proposed for the scattering of SH-waves by foundations of irregular shape and the resulting soil-structure interaction problems. The scattering of elastic waves by the rigid foundation embedded in half-space is solved approximately by using integral representation of the wave equation. The procedure is the Born approximation which has been widely used in quantum mechanics for collision and scattering theory though not well-known in elastodynamics. This paper extends the previous work of the authors on the scattering of waves to account for soil-structure interaction.

81-1828

Dynamic Response of Flexible Rectangular Foundations on an Elastic Half-Space

M. Iguchi and J.E. Luco

Dept. of Architectural Engrg., Faculty of Science and Engrg. Science, Univ. of Tokyo, Noda City, Japan, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 239-249 (May/June 1981) 7 figs, 2 tables, 15 refs

Key Words: Interaction: soil-structure, Foundations, Flexible foundations, Stiffness coefficients, Damping coefficients

An approximate method for the analysis of the dynamic interaction between a flexible rectangular foundation and the soil with consideration of the out-of-plane deformation of the foundation is presented. The procedure is based on an extension of the subdivision method developed by Wong and Luco for rigid foundations. Numerical results describing the influence of the flexibility of the foundation on the vertical and rocking impedance functions and on the contact stresses between the foundation and the soil are presented.

81-1829

Vibration Protection of Systems with Distributed Parameters under Periodic and Shock Excitations (Schwingungsabschirmung in Systemen mit verteilten Parametern bei periodischer und stossartiger Anregung)

J. Wauer

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 201-207 (1980) 5 figs, 6 refs

(In German)

Key Words: Foundations, Beams, Vibration isolation, Periodic excitation

The active or passive shock protection by a beam foundation supported elastically at its ends and damped from the environment, is investigated.

81-1830

Dynamically Loaded Foundations on a Stratified Soil (Dynamisch belastete Fundamente auf geschichtetem Baugrund)

Ph.D.G. Waas

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 185-189 (1980) 5 figs, 9 refs

Key Words: Foundations, Soils, Machine foundations

A fast and reliable method for the calculation of deflections of a layered medium, caused by periodic horizontal or vertical loads, such as dynamically loaded foundations, is described. For this purpose, the medium is simply subdivided in the horizontal direction. Viscoelastic behavior of the medium is considered.

HARBORS AND DAMS

81-1831

Longitudinal Vibration of Non-Homogeneous Earth Dams

A.M. Abdel-Ghaffar and A.-S. Koh
Dept. of Civil Engrg., Princeton Univ., Princeton, NJ, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 279-305 (May/June 1981) 12 figs, 7 tables, 25 refs

Key Words: Dams, Natural frequencies, Mode shapes, Longitudinal vibration, Earthquakes

Two-dimensional analytical elastic models are developed for evaluating dynamic characteristics, namely natural frequencies and modes of vibration of a wide class of earth dams in a direction parallel to the dam axis. In these models the non-homogeneity of the dam materials is taken into account by assuming a specific variation of the stiffness properties along the depth (due to the continuous increase in confining pressure). In addition, both shear and normal (axial) deformations are considered. Cases having constant elastic moduli, linear and trapezoidal variations of elastic moduli, and elastic moduli increasing as the one-half, one-third, two fifths, and a general (l/m)th powers of the depth are studied. Dynamic properties of three real earth dams in a seismically active area (Southern California) estimated from their earthquake records (input ground motion and crest response in the longitudinal direction) as well as results from full-scale dynamic tests on one of these dams (including ambient and forced vibration tests) are compared with those from the suggested models. It was found that the models in which the shear modulus and the modulus of elasticity of the dam material vary along the depth are the most appropriate representations for predicting the dynamic characteristics. The agreement between the experimental and earthquake data and the theoretical results from some of the models is reasonably good.

PRESSURE VESSELS

81-1832

Acoustic Emission Testing During a Burst Test of a Thick-Walled 2-1/4 Cr-1 Mo Steel Pressure Vessel

T. Tsukikawa, S. Yamamoto, Y. Ohshio, M. Nakano, H. Ueyama, J. Watanabe, K. Ohnishi, R. Saikudo, and T. Iwadate
Civil and Applied Mech. Res. Dept., Chiyoda Chemical Engrg. and Construction Co. Ltd., Kawasaki, Japan, J. Pressure Vessel Tech., Trans. ASME, 102 (4), pp 353-362 (Nov 1980) 11 figs, 7 tables, 26 refs

Key Words: Acoustic emission, Acoustic tests, Pressure vessels

The applicability of AET to pressure vessels made of 2 1/4 Cr-1 Mo steel was studied by an extensive program which included: a hydrostatic test of a test vessel with weld discontinuities, a burst test of a test vessel with precracks, and an analysis of the results using a fracture mechanics approach. The results obtained clearly demonstrate that AET is a useful tool for shop and in-field inspections.

POWER PLANTS

(Also see Nos. 1811, 1825, 1939, 1943)

81-1833

Dynamical Models and Numerical Simulation of System-Wide Transients in Loop-Type LMFBRS

M. Khatib-Rahbar and K.B. Cady
Dept. of Nucl. Energy, Brookhaven Natl. Lab., Upton, NY 11973, Nucl. Engrg. Des., 64 (2), pp 259-281 (Apr 1981) 20 figs, 4 tables, 42 refs

Key Words: Nuclear reactors, Simulation, Transient response

Dynamical models and numerical methods for a digital simulation of protected transients in loop-type liquid-metal cooled fast breeder reactors resulting in EPRI-CURL code are presented. The model is capable of simulating operational transients, anticipated incidents, and postulated accidents which do not lead to sodium boiling. The dynamical models include: point reactor kinetics, primary, intermediate, and tertiary system heat transfer and coolant flow dynamics governed by forced and natural convection effects; and plant protection and control systems. A numerical method is incorporated which calculated the characteristic times of the 489 state variables modeling the entire system, and compares them with a variable preset integration timestep. A Runge-Kutta algorithm is applied to those state variables with moderate and slow response, and a quasistatic approximation is applied to those with rapid response; i.e., the 'stiff' equations.

81-1834

Prediction of Random High-Cycle Fatigue Life of LWR Components

Y.S. Shin
General Electric Co., San Jose, CA 95020, J. Pressure Vessel Tech., Trans. ASME, 102 (4), pp 378-386 (Nov 1980) 10 figs, 46 refs

Key Words: Nuclear reactors, Fatigue life, Random vibration, Fluid-induced excitation

This state-of-the-art review identifies and discusses the existing methods of predicting the high-cycle fatigue life,

their limitations, and base-technology needs. The cycle stress-strain approach and the random vibration approach are reviewed, evaluated and discussed. It is applicable to estimating high-cycle fatigue damages of Light Water Reactor (LWR) components under the random excitation typical of flow-induced vibration.

81-1835

Methods and Benefits of Experimental Structural Dynamic Evaluation of Nuclear Power Plants

P. Ibáñez, S. Chien, M. Dinyavari, M. Dobbs, W. Gundy, G. Howard, R. Keowen, P. Rentz, C. Smith, J. Stoessel, W. Walton, and C. Sires-Yifat

ANCO Engineers, Inc., Santa Monica, CA 90404, Nucl. Engrg. Des., 64 (1), pp 1-32 (Mar 1981) 3 figs, 7 tables, 31 refs

Key Words: Nuclear power plants, Vibration tests, Seismic design, Reviews

This study reviews past projects, experimental techniques, instrumentation requirements, safety considerations, and the benefits of performing vibration tests on nuclear power plant containments and internal components. The emphasis is on testing to improve seismic structural models although the methods are applicable to any form of dynamic excitation. Established techniques for testing and for identification of resonant frequencies, damping, and mode shapes are presented. The benefits of testing with regard to verifying increased damping values and establishing more accurate computer models are outlined. Finally, a forced vibration test project planned to realize these benefits is presented for a typical nuclear power plant.

OFF-SHORE STRUCTURES

(Also see No. 1908)

81-1836

Streamwise Oscillations of Cylinders

W.W. Martin, I.G. Currie, and E. Naudascher

Dept. of Mech. Engrg., Univ. of Toronto, Toronto, Canada, ASCE J. Engrg. Mechanics Div., 107 (3), pp 589-607 (June 1981) 10 figs, 18 refs

Key Words: Off-shore structures, Pile structures, Cylinders, Fluid-induced excitation, Amplitude analysis

Slender structures, such as marine piles, have been observed to experience oscillations in a streamwise direction when exposed to an external flow under appropriate circumstances. This phenomenon is explored both theoretically and analytically with a view to explaining the basis of the phenomenon and of providing a method of calculating the response amplitude. The flow around a vibrating body is assumed to be quasisteady. From this assumption a stability criterion, analogous to the Den Hartog criterion for transverse oscillation, is derived. This stability criterion indicates that instability is to be expected only over a range of Reynolds number near the critical value which corresponds to a sudden drop in the drag coefficient and an increase in the Strouhal number. Using a linear oscillator model for the body, an analysis is performed to seek solutions for the vibration amplitude. The results of this analysis are compared with observations of prototype oscillations of marine piles which occurred at Reynolds numbers high enough to be in the critical range.

81-1837

Fatigue Analysis of the Cognac Platform

R.K. Kinra and P.W. Marshall

Shell Oil Co., J. Pet. Tech., 32 (3), pp 374-386 (Mar 1980) 13 figs, 6 tables, 16 refs

Key Words: Drilling platforms, Off-shore structures, Fatigue life

This paper describes preliminary and detailed fatigue analyses of the 1,000-ft-deep Cognac platform. Dynamic structural analysis is used to generate local member stress transfer function data, and probabilistic spectral techniques are employed to evaluate long-term stress statistics and fatigue lives using Miner's cumulative damage rule. Directional spreading of wave energy is considered in the analysis.

81-1838

Earthquake Survivability of Concrete Platforms

B.J. Watt, I.B. Boaz, J.A. Ruhl, S.A. Shipley, D.J. Dowrick, and A. Ghose

SPE Brian Watt Assoc., Inc., J. Pet. Tech., 32 (6), pp 1090-1104 (June 1980) 17 figs, 3 tables, 21 refs

Key Words: Off-shore structures, Drilling platforms, Concretes, Earthquake response

Nonlinear dynamic analyses were conducted to assess the survivability of concrete gravity platforms during extreme earthquakes. Structure, foundation, and earthquake characteristics were varied among 15 analysis cases. It was concluded that suitably designed platforms can survive ground-shaking conditions likely to be associated with rare intense earthquakes in the Gulf of Alaska.

81-1839

Analysis of Full-Scale Wind Forces on a Semisubmersible Platform Using Operator's Data

H. Boonstra

Ingenieursbureau Marcon, J. Pet. Tech., 32 (5), pp 771-776 (May 1980) 7 figs, 3 refs

Key Words: Off-shore structures, Wind-induced excitation, Drilling platforms

Measurements of chain tension and wind velocity aboard a semisubmersible drilling platform have been analyzed, resulting in an empirical relation between wind velocity and wind force. A comparison of the empirical and theoretically calculated forces shows that the actual wind force is appreciably smaller.

81-1840

The Dynamics of Tension Leg Platforms in Waves

T. Yoneya and K. Yoshida

Research Inst., Nippon Kaiji Kyokai, Japan, ASME Rept. No. 81-Pet-27

Key Words: Off-shore structures, Water waves

The dynamic response characteristics of the taut moored platform or the so-called tension leg platform in regular waves are studied both by several series of tank tests with small-scale models and by the simplified methods of linear and nonlinear analyses.

81-1841

Motion and Load Prediction of Floating Pipelaying Equipment

H.L. Minkenberg and T.S. Gie

Netherlands Ship Model Basin, J. Pet. Tech., 32 (7), pp 1281-1291 (July 1980) 13 figs, 33 refs

Key Words: Barges, Fluid-induced excitation, Water waves

In predicting the motions and loads of floating pipelaying equipment – varying from conventional barges to large, highly sophisticated semisubmersibles – several mathematical methods and model experimental techniques are available. This paper reviews the various mathematical methods and correlates the results with model test and prototype data.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 1877, 1882, 1974)

81-1842

Contribution to Sound Propagation in Motor Vehicles (Zur Schallausbreitung in Fahrzeugen)

K. Kurz

A. Stankiewicz, GmbH, Postfach 278, 3100 Celle, Fed. Rep. Germany, Automobiltech. Z., 83 (4), pp 157-160 (Apr 1981) 7 figs, 10 refs

(In German)

Key Words: Motor vehicle noise, Noise reduction

This paper discusses an equation to explain the experimental results of noise reduction in the passenger compartment of motor vehicles.

81-1843

Interior Noise Reduction by Computer-Aided Analysis Methods (Innengeräuschreduzierung durch rechnergestützte Analyseverfahren)

H. Bathelt

Automobiltech. Z., 83 (4), pp 163-168 (Apr 1981) 11 figs, 1 table, 2 refs

(In German)

Key Words: Automobiles, Noise reduction, Computer-aided techniques

Low frequency noise inside a passenger car is caused by engine vibrations transmitted by all connections of the engine to the body and radiated into the passenger compartment. Computer-aided digital signal analysis enables quick and exact measurement of the acoustic transfer functions of a body describing its behavior in transmitting structural noise. By combination of these transfer functions with indirect measurements of the dynamic forces acting on the body it is possible to calculate the contribution of a single transmission path, e.g. the engine mounts to the interior noise level without mechanical interruption.

81-1844

Reducing Exhaust System Noise in Heavy Truck Design

M. Inagawa and K. Nakamura

Vehicle Research Section, Mitsubishi Motors Corp., Kawasaki-shi, Japan, Intl. J. Vehicle Des., 2 (2), pp 127-144 (May 1981) 19 figs, 4 tables, 3 refs

Key Words: Traffic noise, Trucks, Noise reduction

Traffic noise in urban areas is posing a serious problem in many countries of the world, and the reduction of noise in heavy trucks is now a social problem urgently requiring resolution. Four major heavy truck manufacturers have been conducting joint research on the reduction of noise in heavy trucks under the leadership of the Japanese Ministry of International Trade and Industry as a three-year project. The Mitsubishi Motors Corporation is in charge of the reduction of exhaust system noise, which is one of the main sources of vehicle noise. The exhaust system noise of trucks can be divided into discharge noise emitted from the exhaust outlet and radiated noise emanating from the surface of the exhaust pipes and mufflers. This paper reports on the results of experiments performed on the reduction of the exhaust noise of actual trucks on the basis of the results of basic studies, including acoustic studies and studies of air flow noise and radiated noise.

81-1845

The Influence of Tire Factors on the Stability of Trucks and Tractor Trailers

L. Segel and R.D. Ervin

Highway Safety Res. Inst., Univ. of Michigan, Ann Arbor, MI 48109, Vehicle Syst. Dyn., 10 (1), pp 39-59 (Feb 1981) 18 figs, 2 tables, 7 refs

Key Words: Articulated vehicles, Trucks, Tire characteristics

The mechanical properties of tires and trucks are contrasted with comparable properties of the motor car to explain why the motor truck and the tractor-trailer can exhibit fixed-control instability at moderate levels of lateral acceleration. The rearward bias in the distribution of roll stiffness, large ratio of c.g. height to track, and low torsional stiffness of the parallel-rail frame (as typically employed in heavy commercial vehicles) are found to be the major factors implicated in this phenomenon. Experimental and analytical evidence is provided to show how tire inflation pressure and mixes of tire-carcass construction and tread design also influence stability at moderate levels of lateral acceleration. Conclusions relating to the safety of commercial vehicle operations are drawn.

81-1846

Application Orientated Investigation Methods of the Steering Behavior of Motor Vehicles (Anwendungsorientierte Untersuchungsmethoden des Lenkverhaltens von Kraftfahrzeugen)

F. Panik, J. Drosdol, and L. Auersch

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 89-98 (1980) 19 figs, 4 refs

(In German)

Key Words: Motor vehicles, Ride dynamics, Steering effects

Methods for model building and measurement and evaluation techniques for the analysis of ride dynamics problems are investigated using steering behavior of a motor vehicle as an example. The goal of the procedure is to adjust the model system and the measurement system in such a way that the recorded data could be directly used in the model and applied for parameter identification.

81-1847

Vehicle Handling Characteristics and Their Relationship to Vehicle Design Parameters (Kurshaltungskennwerte und ihre Abhängigkeit von Fahrzeugdaten)

A. Horn and P. Voelsen

Institut f. Fahrzeugtechnik, Technische Universität Braunschweig, Germany, Vehicle Syst. Dyn., 10 (1), pp 1-19 (Feb 1981) 12 figs, 15 refs

(In German)

Key Words: Ground vehicles, Ride dynamics, Time domain method, Frequency domain method

This paper reviews currently used test procedures for the determination of vehicle handling characteristics in the time and frequency domain. Driver subjective opinions lead to preferred tendencies or ranges of these quantities. The results of closed-loop tests show the adaptability of drivers to the dynamic characteristics of vehicles. The relationship between handling characteristics and design parameters is obtained from the analysis of a simple vehicle model. Comparison of these results with the preferred ranges found in closed-loop tests yields aids for the design of vehicles.

81-1848

The Effects of Lateral Front Fork Flexibility on the Vibrational Modes of Straight-Running Single-Track Vehicles

P.T.J. Spierings

Univ. of Technology, Eindhoven, The Netherlands, Vehicle Syst. Dyn., 10 (1), pp 21-35 (Feb 1981) 8 figs, 11 refs

Key Words: Ground vehicles, Motorcycles, Mode shapes

By means of a mathematical model the effects of lateral front fork flexibility on the vibrational modes of single-track vehicles have been studied. The analysis performed by Sharp has been used as a starting point. The results have been compared with Roe's empirical findings. The results of the analysis have been translated into practical advice for a more optimal front fork construction.

81-1849

Lateral Elastically Suspended Engines for Increasing the Limit Speed of Tracked Vehicles (Querelastisch aufgehängte Fahrmotoren zur Erhöhung der Grenzgeschwindigkeit von Rad/Schiene-Fahrzeugen)

A. Mielcarek and P. Meinke

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 105-111 (1980) 9 figs, 3 tables, 2 refs

(In German)

Key Words: Railroad trains, Ride dynamics, High speed transportation systems, Engine mounts

The possibilities for improving the ride dynamics of rail vehicles at high speeds by the installation of a lateral elastically suspended engine is investigated. Seven design possibilities of the suspension are investigated and compared.

81-1850

Lateral Stability of Flat Rail Cars - An Over-the-Road Investigation

M.M. ElMadany and P.V. RamaChandran

Wyle Laboratories, Colorado Springs, CO, Intl. J. Vehicle Des., 2 (2), pp 162-173 (May 1981) 15 figs, 2 tables, 4 refs

Key Words: Railroad cars, Hunting motion, Statistical analysis

As part of the (Rail) Truck Design Optimization Project (TDOP), Phase II, data acquired from over-the-road tests have been reduced and analyzed to define the dynamic characteristics of flat rail cars equipped with low-level constant-friction snubbed rail trucks. The investigation has focused on the influence of lading condition, wheel profile, speed and track excitations (jointed rail track and continuous welded rail track) on the lateral stability of flat cars. The objectives of this study are to define the statistical characteristics of the flat car lateral stability and to demonstrate and evaluate the performance of such vehicles.

81-1851

Urban Rail Transportation Systems - Their Vibration Emission and Environmental Protection (Schienengebundene Systeme im Stadtverkehr - Ihre Schwingungsemission und der Umweltschutz)

J. Melke

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 191-199 (1980) 16 figs

(In German)

Key Words: Railroad trains, Urban transportation, Vibration generation, Experimental test data

Test data, showing the effects of the shape of the track, railroad yard, line operation, and the speed of the vehicle on vibration emission of an urban rail transportation system, are presented.

81-1852

The Excitation of Rail-Wheel System Parameters (Parametererregung beim Rad-Schiene-System)

J. Korb

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 99-104 (1980) 8 figs, 4 refs

(In German)

Key Words: Interaction: rail-wheel, Flexural vibration, Railroad tracks, Variable material properties

Parameter excitation of the rail-wheel system caused by the continuously variable elasticity of the rail is determined and analyzed. The frequency range of 10 Hz to about 150 Hz is investigated. Two models are derived. The general model describes the transverse vibrations of the rails as a continuum - taking the coupled wheel mass into consideration. The reduced model, obtained from the general model by means of the mode shape analysis, describes the vibration condition of the rail-wheel system at the wheel support point.

81-1853

Effects of Fan, Ducting and Powerplant Characteristics on the Cushion Stability of Air Cushion Vehicles

H. Matsuo and K. Matsuo

Kumamoto Univ., Kumamoto, Japan, J. Aircraft, 18 (5), pp 372-376 (May 1981) 4 figs, 12 refs

Key Words: Ground effect machines, Fans, Ducts

A theoretical study on the cushion stability of vertically oscillating air cushion vehicles, including the peripheral and the plenum chamber craft, is reported. In the analysis, the influences of fan, ducting and powerplant characteristics, which are frequently disregarded in existing analyses, are fully considered and general formulas which include both the peripheral and the plenum chamber craft are derived.

81-1854

Experimental Study on Moving Loads on a Floating Sea Ice Road

R.A. Haspel, D.M. Masterson, R.J. Goff, and R.E. Potter

Fenco Consultants, Ltd., Calgary, Alberta, Canada, J. Engrg. Resources Tech., Trans. ASME, 103 (1), pp 96-105 (Mar 1981) 13 figs, 4 tables, 11 refs

Key Words: Floating ice, Ice, Moving loads, Trucks, Dynamic tests

On a 14.5-km (9-mi) floating sea ice road at the North Slope of Alaska dynamic load tests were performed with a 68-tonne (75-ton) gravel truck. The results were in good agreement with the theory of moving loads on floating ice and with the design concept of floating ice structures. In tests over a road with and without bumps, values for dynamic amplification were measured. The test results represent a definite advancement of the state-of-the-art in design and use of floating ice for transportation.

SHIPS

81-1855

The Reduction of Ship Vibrations by Means of Electrically Driven Controlling Force Exciter (Tilgung von Schiffsschwingungen mit Hilfe elektrisch angetriebener Richtkrafterreger)

G. Donath and W. Axt

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 1-10 (1980) 12 figs, 8 refs

(In German)

Key Words: Ships, Vibration control

One possibility for combating ship vibrations is described. It deals with the global vibrations of the entire ship body -- excited by the free mass moments of the large crosshead-two stroke diesel engines.

81-1856

Hydrodynamic Forces Caused by Ship in Confined Waters

R.F. Beck

Dept. of Naval Architecture and Marine Engrg., Univ. of Michigan, Ann Arbor, MI 48109, ASCE J. Engrg. Mechanics Div., 107 (3), pp 523-546 (June 1981) 12 figs, 39 refs

Key Words: Ships, Hydrodynamic excitation

The use of slender-body theory to predict the hydrodynamic disturbance caused by a ship maneuvering in confined waters is reviewed. Various configurations are described including: shallow water; canals; dredged channels; and ship-to-ship interactions. Particular attention is paid to the determination of the sinkage, trim, lateral force and yaw moment. Examples are also given to the pressure distribution over the bottom and on the canal walls. Several general conclusions are drawn. The important speed parameter is the Froude number based on depth. Near the critical value of $F_h = 1.0$, the simple linear analysis used is no longer valid. Secondly, as the waterway becomes more restrictive (i.e., as the water depth or width, or both, decreases), the forces acting on the vessel increase dramatically. This results in an increase in the squat and greater difficulty in controlling the ship.

AIRCRAFT

(Also see Nos. 1970, 2029, 2035)

81-1857

A Review of Aircraft Noise Propagation

D.F. Pernet

Acoustics Unit, Natl. Physical Lab., Teddington, UK,

Rept. No. NPL-Ac-92, 69 pp (Oct 1979)
N81-19879

Key Words: *Aircraft noise, Sound propagation, Reviews*

Factors affecting the attenuation rate measurement accuracy from investigations of aircraft noise propagation were examined. Estimates of the relative importance of these factors are made, considering in particular noise source, atmospheric medium and acoustic measurement. A number of studies were examined in detail and recommendations are made on how to improve data reliability and data interpretation.

81-1858

Empirical Method for the Prediction of Business Executive Jet Cabin Noise Levels

N.M. Moses and T. Roxner
Acoustics Dept., Israel Aircraft Industries Ltd., Ben-Gurion Airport, Israel, Appl. Acoust., 14 (1), pp 33-42 (Jan-Feb 1981) 10 figs, 1 ref

Key Words: Aircraft noise, Noise measurement, Noise prediction

As a result of flight noise measurements made at various locations in the cabin of the standard lined/no interior Westwind model 1124 business executive jet, it was possible to develop an empirical method for predicting the overall sound pressure level (OASPL) at any required location in the cabin. The cabin overall sound level in decibels (linear) may be found from nomographs related to aircraft altitude, mach number or velocity. The noise spectrum at any location may be found from a reference spectrum shape corrected for local parameters. The accuracy of the prediction method, verified by additional tests, was found to be ±1 dB.

81-1859

Aerodynamic/Acoustic Performance of YJ101/Double Bypass VCE with Coannular Plug Nozzle

J.W. Vdoviak, P.R. Knott, and J.J. Ebacker
General Electric Co., Aircraft Engine Business Group, Cincinnati, OH, Rept. No. NASA-CR-159869, 307 pp (Jan 1981)
N81-17846

Key Words: Aircraft noise, Noise reduction

Results of a forward Variable Area Bypass Injector test and a Coannular Nozzle test performed on a YJ101 Double Bypass Variable Cycle Engine are reported. These components are intended for use on a Variable Cycle Engine. The forward Variable Area Bypass Injector test demonstrated the mode shifting capability between single and double bypass operation with less than predicted aerodynamic losses in the bypass duct. The acoustic nozzle test demonstrated that coannular noise suppression was between 4 and 6 PNdB in the aft quadrant. The YJ101 VDE equipped with the forward VABI and the coannular exhaust nozzle performed as predicted with exhaust system aerodynamic losses lower than predicted both in single and double bypass modes. Extensive acoustic data were collected including far field, near field, sound separation/internal probe measurements as Laser Velocimeter traverses.

81-1860

The Radiation of High Frequency Sound from a Jet Pipe

A.M. Cargill
Rolls-Royce Ltd., Noise Dept., Derby, UK, Rept. No. PNR-90046, 11 pp (1980)
N81-17855

Key Words: Aircraft noise, Jet noise, Sound waves, Sound propagation

The radiation of sound from a semi-infinite cylindrical pipe with internal and external flows is discussed. Two approximate solutions are presented, based on Kirchhoff diffraction theory and edge scattering, and are compared with an exact solution by the Wiener-Hopf technique. The radiation from a baffled opening with a jet pipe is also discussed. The differences between this simple model and an aircraft engine are compared showing how the results are modified by the presence of a secondary flow (e.g., the fan stream on a turbofan engine), by the existence of a contracting nozzle, and by the scattering of the sound by jet shear layer turbulence. For the latter, results in excellent qualitative agreement with observations on real engines are obtained.

81-1861

Recent Developments in Aircraft Engine Noise Reduction Technology

J.R. Stone and C.E. Feiler
NASA Lewis Res. Ctr., Cleveland, OH, The 1980 Aircraft Safety and Operating Probl. Pt. 2, pp 671-698 (Mar 1981)
N81-19072

Key Words: Aircraft noise, Noise reduction, Jet noise, Fan noise

Some of the more important developments and progress in jet and fan noise reduction and flight effects are reviewed. Experiments are reported which show that nonaxisymmetric coannular nozzles have the potential to reduce jet noise for conventional and inverted velocity profiles. It is shown that an improved understanding of suppressive linear behavior, coupled with the new understanding of fan source noise, will soon allow the joint optimization of acoustic liner and fan design for low noise. It is also shown that fan noise source reduction concepts are applicable to advanced turboprops. Advances in inflow control device design are reviewed that appear to offer an adequate approach to the ground simulation of inflight fan noise.

81-1862

Airport Noise Impact Reduction Through Operations

R. Deloach

NASA Langley Res. Ctr., Hampton, VA, The 1980 Aircraft Safety and Operating Probl., Pt. 2, pp 759-778 (Mar 1981)

N81-19075

Key Words: Aircraft noise, Noise reduction

The effects of various aeronautical, operational, and land-use noise impact reduction alternatives are assessed for a major midwestern airport. Specifically, the relative effectiveness of adding sound absorbing material to aircraft engines, imposing curfews, and treating houses with acoustic insulation are examined.

81-1863

Sources, Control, and Effects of Noise from Aircraft Propellers and Rotors

J.S. Mixson, G.C. Greene, and T.K. Dempsey

NASA Langley Res. Ctr., Hampton, VA, The 1980 Aircraft Safety and Operating Probl., Pt. 2, pp 699-720 (Mar 1981)

N81-19073

Key Words: Aircraft noise, Propeller noise, Helicopter noise, Noise reduction, Human response

Source noise predictions are compared with measurements for conventional low-speed propellers, for new high speed propellers (propfans), and for a helicopter. Results from a light aircraft demonstration program are described, indicating that about 5-dB reduction of flyover noise can be obtained without significant performance penalty. Sidewall design studies are described for interior noise control in light general aviation aircraft and in large transports using propfan propulsion. The weight of the added acoustic treatment is estimated and tradeoffs between weight and noise reduction are discussed. A laboratory study of passenger response to combined broadband and tonal propeller like noise is described. Subject discomfort ratings of combined tone broadband noises are compared with ratings of broadband (boundary layer) noise alone, and the relative importance of the propeller tones is examined.

81-1864

NASA Progress in Aircraft Noise Prediction

J.P. Raney, S.L. Padula, and W.E. Zorumski

NASA Langley Res. Ctr., Hampton, VA, The 1980 Aircraft Safety and Operating Probl., Pt. 2, pp 721-757 (Mar 1981)

N81-19074

Key Words: Aircraft noise, Noise prediction

Some of the essential features of aircraft noise prediction are described and the basis for evaluating its capability and future potential is discussed. A takeoff noise optimizing procedure is described which calculates a minimum noise takeoff procedure subject to multiple site noise constraints.

81-1865

Convective Amplification of Gas Turbine Engine Internal Noise Sources

R.S. Larson

Pratt and Whitney Aircraft Group, Commercial Products Div., United Technologies Corp., East Hartford, CT 06108, J. Sound Vib., 74 (1), pp 123-137 (Jan 8, 1981) 6 figs, 12 refs

Key Words: Aircraft noise, Gas turbine engines, Engine noise, Amplification

The acoustic field of a noise source is altered when the source is in motion. The change in the acoustic field introduced by the source motion, caused by source alteration and propagation effects, is defined as convective amplification. Previous studies of this phenomenon have been based on analytical models that did not incorporate the physical features necessary for calculation of the convective amplification factor for the internal noise sources of a gas turbine engine, which is required to predict in-flight noise levels from static engine noise measurements. An improved theoretical model was developed.

81-1866

Gust Response of Rotor and Propeller Systems

G.H. Gaonkar

Indian Inst. of Sci., Bangalore, India, J. Aircraft, 18 (5), pp 389-396 (May 1981) 10 figs, 76 refs

Key Words: Aircraft, Wind-induced excitation

The influence of nonstationary turbulence on rotor and propeller systems is discussed. The review is made from a common analytical basis of nonstationary approach, with emphasis on concepts rather than on details. The necessity of such an approach and its feasibility for predicting a complete set of gust and response statistics together with correlations with somewhat limited test data are appraised.

81-1867

Maximum Likelihood Identification of Aircraft Lateral Parameters with Unsteady Aerodynamic Modelling

S.S. Banda

Ph.D. Thesis, Univ. of Dayton, 198 pp (1980)
UM 8107428

Key Words: Aircraft, Parameter identification technique

A simplified aerodynamic force and moment model for unsteadiness in the sideslipping flight was developed via an indicial sidewash function and an indicial sideforce function. The presence of convolution integrals in the equations of motion led to the Fourier transformation of these equations into the frequency domain. A parameter extraction algorithm based on the maximum likelihood estimation technique was developed in the frequency domain. This algorithm was applied to pseudo data as well as real flight data.

81-1868

The Development of a Theoretical and Experimental Model for the Study of Active Suppression of Wing Flutter

D.E. Dashcund

Ph.D. Thesis, Princeton, Univ., 432 pp (1981)
UM 8108087

Key Words: Aircraft wings, Active flutter control

A theoretical model is developed in conjunction with an experimental wind tunnel model to study active suppression of classical bending-torsion wing flutter using feedback control. The wing model studied consists of a uniform, semi-span, cantilevered plate-wing with an external, partial span, trailing edge control surface actuated by means of a control rod running along the wing's trailing edge. An electro-mechanical actuator, mounted inboard of the wing root, deflects the control surface in response to sensed wing motion so as to suppress aeroelastic instabilities.

81-1869

Demonstration of a Method for Determining Critical Store Configurations for Wing Store Flutter. Final Report

R.R. Chipman and E.J. Laurie

Grumman Aerospace Corp., Bethpage, NY, Rept. No. AD-A-92257, ADCR-80-1, 132 pp (May 1980)
N81-16068

Key Words: Aircraft, Flutter, Wing stores

The A-6E aircraft and its extensive store inventory were analyzed. Searches of the inventory singled out the potentially critical configurations that gave flutter speeds well within the flight envelope for low assumed values of structural damping. Comparisons were made with previous results from A-6 studies and possible explanations for the apparent anomaly were explored. The method offers an efficient alternative to existing practices for determining potentially flutter critical store combinations from the many thousands of store loadings that can occur on attack aircraft.

81-1870

On the Fatigue Life with Varying Stress Amplitudes

C.-h. Zeng, R.-Y. Deng, Y.-s. Wu, and J.-s. Du

Inst. of Mechanics, Academia Sinica, Peoples Rep. China, Acta Mech. Solida Sinica, Chinese Soc. Theor. and Appl. Mechanics, No. 1, pp 38-47 (1980) 9 figs, 9 tables, 19 refs
(In Chinese)

Key Words: Fatigue life, Aircraft, Structural members

This paper discusses estimate methods for the fatigue life of a component or an aircraft structure. Based on a large number of program-fatigue tests on notched specimens, the effects of the factors, such as mean stress, small number of high stress cycles, stress sequence, program block length, G-A-G cycles, etc. on fatigue life are explained theoretically and experimentally.

81-1871

The NASA Digital VGH Program, Early Results

N.L. Crabill and G.J. Morris

NASA Langley Res. Ctr., Hampton, VA, The 1980 Aircraft Safety and Operating Probl., Pt. 2, pp 613-624 (Mar 1981)

N81-19069

Key Words: Aircraft, Fatigue life, Statistical analysis, Wind-induced excitation

Data from airline digital flight data recorders provides relevant statistical data for estimating fatigue life consumption of the current airliner fleet and for design criteria updating for future designs. The data indicates real operating effects due to the autopilot, i.e., gust response frequency peak increase by 2 or 3 times, and the existence of the low frequency low amplitude limit cycle motion in altitude hold. The extension of more data types for ground operations is considered. Onboard processing of simple data types is also considered.

81-1872

Evaluation of Emergency-Locator-Transmitter Performance in Real and Simulated Crash Tests

H.D. Carden

NASA Langley Res. Ctr., Hampton, VA, The 1980 Aircraft Safety and Operating Probl., Pt. 2, pp 625-653 (Mar 1981)

N81-19070

Key Words: Crash research (aircraft), Detectors

Emergency locator transmitter (ELT) activation problems were investigated by testing a sampling of ELT units in actual airplane crashes and in a special test apparatus which simulated longitudinal crash pulses with superimposed local structural resonances. Probable causes of excessive false alarms and nonactivations of ELT's during crash situations were determined and solutions to the current operational and technical problems were obtained. The results, which considered placement, mounting, and activation of ELT's under simulated crash impacts, and an evaluation of the sensitivity of ELT impact switches to orientation and to local structural vibrations are discussed.

81-1873

NASA/FAA General Aviation Crash Dynamics Program

R.G. Thomson, R.J. Hayduk, and H.D. Carden

NASA Langley Res. Ctr., Hampton, VA, The 1980 Aircraft Safety and Operating Probl., Pt. 2, pp 511-540 (Mar 1981)

N81-19064

Key Words: Crash research (aircraft), Energy dissipation, Prediction techniques, Computer-aided techniques

The program involves controlled full scale crash testing, nonlinear structural analyses to predict large deflection elastoplastic response, and load attenuating concepts for use in improved seat and subfloor structure. Both analytical and experimental methods are used to develop expertise in these areas. Analyses include simplified procedures for estimating energy dissipating capabilities and comprehensive computerized procedures for predicting airframe response. These analyses are developed to provide designers with methods for predicting accelerations, loads, and displacements on collapsing structure. Tests on typical full scale aircraft and on full and subscale structural components are performed to verify the analyses and to demonstrate load attenuating concepts. A special apparatus was built to test emergency locator transmitters when attached to representative aircraft structure. The apparatus is shown to provide a good simulation of the longitudinal crash pulse observed in full scale aircraft crash tests.

81-1874

Use of Optimization in *Helicopter* Vibration Control by Structural Modification

G.T.S. Done and M.A.V. Rangacharyulu

Dept. of Mech. Engrg., The City Univ., Northampton Square, London EC1V OHB, UK, J. Sound Vib., 74 (4), pp 507-518 (Feb 22, 1981) 5 figs, 5 tables, 9 refs

Key Words: Helicopter vibration, Vibration control, Optimization

The application of a mathematical optimization process to helicopter vibration control by structural modification is described. Attention is focused on the reduction of vibration in the crew area. With stiffness parameters as design variables, use is made of forced vibration response circles to identify the parameters most effective in controlling the response in the crew area, thereby reducing the number of available design variables to a tractable size. The problem of reducing vibration is then cast as a non-linear programming problem and a sequential unconstrained minimization technique incorporating an algorithm based on the methods of Davidon, Fletcher and Powell is used to determine the precise values of the parameters. The method is applied to a simple two-dimensional beam-element helicopter fuselage model and the results discussed. Although the model is too simple for useful

deductions of practical significance to be made in the strictly engineering sense, the exercise does demonstrate what can and cannot be done in controlling vibration by using an optimization routine.

81-1875

Optimum Damper Locations for a Free-Free Beam

G.C. Horner

NASA Langley Res. Ctr., Hampton, VA, The 1980
Large Space System Technol., Vol. 2, pp 5-16 (Feb 1981)
N81-19197

Key Words: Spacecraft, Beams, Optimum damping

Algorithms to optimally locate and design dampers for large space structures were developed. The requirements for distributed sensing and actuation in control of structural systems were determined. Mathematical programming was used to solve for optimum damping rate and location. Actuator dynamics were considered to solve for optimum actuator mass.

BIOLOGICAL SYSTEMS

HUMAN

(Also see Nos. 1863, 1972)

81-1876

The Development of an Annoyance Scale for Community Noise Assessment

N. Levine

Dept. of Urban Planning, Univ. of California at Los Angeles, Los Angeles, CA 90024, J. Sound Vib., 74 (2), pp 265-279 (Jan 22, 1981) 3 figs, 4 tables, 33 refs

Key Words: Urban noise, Human response

The development of an annoyance scale for use in community noise assessment is described. In previous studies in which annoyance scales have been used descriptors, intervals, and metrics have been variable and non-standard. Such variability may be a serious shortcoming in comparing studies of assessment of noise reactions.

81-1877

Traffic Noise Annoyance Near Light Controlled Intersections

R.R.K. Jones and D.M. Waters

Dept. of Transport Tech., Loughborough Univ. of Tech., Loughborough, Leics, UK, Appl. Acoust., 14 (1), pp 7-13 (Jan-Feb 1981) 4 figs, 2 tables, 6 refs

Key Words: Traffic noise, Noise measurement, Noise prediction, Experimental data, Human response

Four hundred noise samples were taken at varying distances from three light-controlled intersections, from which the increments in percentile level above those predicted for the equivalent free flow case were derived.

81-1878

Ergonomic Study of the Influence of Rotary Vibrations (Ergonomische Untersuchungen Ueber Die Einwirkung Rotatorischer Schwingungen. Beanspruchung durch Rollschwingungsbelastung)

W. Ilgmann

Bonn Bundesministerium fuer Verteididung, Rept. No. BMVg-FBWT-79-33, 133 pp (1979)
N81-17714
(In German, English summary)

Key Words: Human response, Vibration excitation

For the measurement of the effects of sinusoidal rotary whole-body vibrations on man, a two-degree of freedom motion simulator for roll and pitch vibrations was designed and built. Using the method of producing stimuli ratios, roll vibration strain up to the tolerance limit was investigated in the frequency range from 1 to 10 Hz. Results demonstrate that the psychophysical law of Stevens is appropriate to describe the relationship between vibration stress and subjective sensation.

81-1879

Reaction of Communities to Impulse Noise

B.V. Seshagiri

Noise Pollution Control Section, Ontario Ministry of the Environment, Toronto, Canada, J. Sound Vib., 74 (1), pp 47-60 (Jan 8, 1981) 5 figs, 4 tables, 9 refs

Key Words: Industrial facilities, Noise generation, Urban noise, Human response

In order to assess the reaction of communities to impulse noise, a sociological survey was conducted in three communities in Ontario, Canada. The dominant industrial noise in these locations is due to drop forging operations. Nearly 600 completed interviews were recorded. Detailed sound level measurements were carried out in the areas surveyed. The results clearly indicate the extent of adverse reaction to the forging noise. This reaction has been compared with the reaction of the respondents to traffic noise prevailing in their communities. Regression lines are presented showing the relationship between the percent of people disturbed by the forging noise and the sound level of the impulses.

ANIMAL

(See No. 2046)

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 1829, 1990)

81-1880

An Investigation into the Mechanism of Sound-Energy Absorption in a Low-Frequency Modular Absorber

R. Walker and K.E. Randall

British Broadcasting Corp., Kingswood, UK, Rept. No. BBC-RD-1980/12, 26 pp (Nov 1980)
N81-16850

Key Words: Absorbers (equipment), Energy absorption, Acoustic absorption, Low frequencies

The behavior of a widely used type of modular, low-frequency acoustic treatment was investigated. A region of spurious sound-energy absorption in the middle part of the audio frequency range, which was originally acceptable, has become more significant in units made since the prototypes were tested in 1969. This has caused excessive absorption in treated rooms in this range of frequencies. A theoretical study based on the supposed behavior of this absorber failed to identify the cause, showing that the supposed behavior was erroneous. Experimental work on a number of modifications to the original design showed that the spurious absorption was caused by damped vibrations of the main structure of the modules. It also showed that the wanted low-frequency absorption resulted from mechanical vibrations of the front-panel, rather than from an acoustic ('Helmholtz') resonance, as had previously been thought.

81-1881

Optimum Absorber Parameters for Minimizing Vibration Response

G.B. Warburton

Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham, UK, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 251-262 (May/June 1981) 8 figs, 4 tables, 5 refs

Key Words: Absorbers (equipment), Vibration absorption (equipment), Optimization

Optimum parameters are determined for absorbers, which, when attached to one mass of a main system with two degrees of freedom, minimize the harmonic response of that mass. Comparison is made with the absorber parameters that are determined by treating the main system as an equivalent one degree-of-freedom system and using classical results. Close agreement is obtained if the ratio of the two natural frequencies of the main system is reasonably large. This is in agreement with the author's recent work on optimum absorber parameters which minimize the response of elastic bodies. The extension of the method to multi degree-of-freedom main systems is outlined. The conditions for which different values of these parameters are predicted when the response is minimized over narrow and broad frequency bands are determined.

81-1882

Attenuation of Traffic Noise Indices L_{eq} and L_N

G. Wegner and C.G. Don

Dept. of Appl. Physics, Caulfield Inst. of Tech., Caulfield East, Victoria 3145 Australia, Appl. Acoust., 14 (2), pp 147-156 (Mar-Apr 1981) 6 figs, 1 table, 8 refs

Key Words: Traffic noise, Acoustic absorption, Equivalent sound levels, Noise barriers

Analysis of the attenuation of L_{eq} and L_N values with distance over grassland from a line of moving traffic indicates that the noise sources effectively radiate energy in the horizontal plane with a distance term different from the commonly assumed inverse square law. This requires an adjust-

ment to the angular corrections for partial screening which now become dependent on the noise index being measured. The attenuation of traffic noise by a wooden fence structure around a suburban house has also been investigated. Shielding effects caused by various components were isolated as the fence structure was sequentially demolished. The shape of the sound field behind the finite length of front fence was deduced, for the various L_N values, by using the amended angular corrections.

81-1883

Cannon Muzzle Noise Suppression Facility Analysis and Tests

H.J. Sneck and D.A. Driscoll
Dept. of Mech. Engrg., Aeronautical Engrg. and Mechanics, Rensselaer Polytechnic Inst., Troy, NY 12181, Noise Control Engrg., 16 (2), pp 81-89 (Mar-Apr 1981) 14 figs, 3 refs

Key Words: Noise reduction, Mufflers, Ammunition

Community complaints about noise from a cannon test facility resulted in the development of a silencer (3.05 metres in diameter by about 21.3 metres in length) for use in testing 105 mm tank cannons. The final design is based on preliminary water-table tests, parallel acoustical and mechanical analysis procedures, and on experience gained with a smaller prototype suppressor for a 20 mm cannon. The small suppressor reduced the 20 mm cannon noise by about 30 dB. The 105 cannon silencer provided sufficient noise reduction (about 10 dB) to end community complaints.

81-1884

Investigations on Mufflers for Internal Combustion Engines

B.C. Nakra, W.K. Sa'id, and A. Nassir
Mech. Engrg. Dept., School of Control and Systems Engrg., Univ. of Tech., Tel-Mohammed, Baghdad, Iraq, Appl. Acoust., 14 (2), pp 135-145 (Mar-Apr 1981) 9 figs, 4 tables, 12 refs

Key Words: Mufflers, Internal combustion engines, Acoustic absorption

This paper deals with experimental studies on reactive types of muffler -- and their combinations with absorption types -- in order to determine their noise attenuation characteristics. Tests were carried out on a test rig, with a loudspeaker as the input source, as well as on a four cylinder diesel engine. The frequency spectra of attenuation levels, obtained experimentally, were compared with corresponding theoretical predictions. In addition, the effect on the performance of the engine itself was studied.

81-1885

Theoretical Foundations for Conventional Investigations of Dynamic Behavior of Elastomers (Theoretische Grundlagen herkommlicher Untersuchungen des dynamischen Verhaltens von Elastomeren)

R. Klingenberg
Zahnräderfabrik Renk AG, Werk Wüfel, Hannover, Germany, VDI-Z, 123 (4), pp 121-128 (Feb 1981) 12 figs, 6 refs
(In German)

Key Words: Elastomers, Damping coefficients, Harmonic excitation

Using an elastic coupling as an example, mathematical relationships are given which describe the dynamic response of a two-mass vibrating system with a viscoelastic spring. A comparison of theoretical and experimental results is shown. The meaning of material damping for thermally stressed elastomers under forced excitation is discussed using the measurement and theoretical results. The expression for the approximation of material damping during instationary excitations at the same time provides a basis for an improved generally valid structural damping expression.

81-1886

Calculation of Rubber Spring Characteristics Using Rubber-Metal Strips as an Example (Die Berechnung von Gummifedern am Beispiel der Gummi-Metall-Schiene)

D. Lehmann
Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte, 381, pp 209-215 (1980) 14 figs, 5 refs
(In German)

Key Words: Elastomers, Bearings, Elastomeric bearings

Methods for the determination of the relationship between force and deflection in elastomeric bearings in the range of operating conditions are discussed.

TIRES AND WHEELS

(Also see No. 1992)

81-1887

Theoretical and Experimental Studies on the Dynamic Properties of Tyres. Part 2: Experimental Investigation of Rubber Friction and Deformation of a Tyre

H. Sakai

Fourth Dept. of Res., Japan Automobile Inst., Ibaraki, Japan, Intl. J. Vehicle Des., 2 (2), pp 182-226 (May 1981) 79 refs, 3 tables, 10 refs

Key Words: Automobile tires, Tires, Tire characteristics, Testing techniques

Experiments designed to determine the basic properties of a tire needed for the calculation of the six components of force and moment are described. Similar consideration is then given to experiments aimed at determining the frictional properties needed for the calculation of the six components.

81-1889

Effects of Mistuning on Bending-Torsion Flutter and Response of a Cascade in Incompressible Flow

K.R.V. Kaza and R.E. Kielb

Univ. of Toledo, Toledo, OH, Rept. No. NASA-TM-81674, 20 pp (1981)

N81-16494

Key Words: Blades, Cascades, Flutter, Flexural response, Torsional response, Coupled response, Computer programs

The effect of small differences between the individual blades (mistuning) on the aeroelastic stability and response of a cascade were studied. The aerodynamic, inertial, and structural coupling between the bending and torsional motions of each blade and the aerodynamic coupling between the blades was considered. A digital computer program was developed to conduct parametric studies. Results indicate that the mistuning has a beneficial effect on the coupled bending torsion and uncoupled torsion flutter. On forced response, however, the effect may be either beneficial or adverse, depending on the engine order of the forcing function. The results also illustrate that it may be feasible to utilize mistuning as a passive control to increase flutter speed while maintaining forced response at an acceptable level.

BLADES

(Also see Nos. 1931, 2029, 2037, 2038, 2039, 2040, 2041)

81-1888

Static Deflection and Eigenfrequency Analysis of the Nibe Wind Turbine Rotors. Theoretical Background

P. Lundsager

Atomic Energy Commission Res. Establishment, Riso, Denmark, Rept. No. RISOE-M-2199, 31 pp (Feb 1980)

N81-19497

Key Words: Blades, Rotor blades (turbomachinery), Beams, Cantilever beams, Wind turbines, Turbines, Natural frequencies

The theory of thin-walled multicell structures is used to calculate the cross-sectional properties of rotor blades. The theory is developed for beams of inhomogeneous materials. The blade is then modeled using the finite element method. A stayed and a cantilevered blade, each consisting of a steel part and a glass fiber part, were analyzed. Static deflection caused by extreme wind load along with the five to ten lowest eigenfrequencies were calculated. Results deviated less than 15 percent from theoretical predictions.

BEARINGS

(Also see Nos. 1813, 2036)

81-1890

Dynamic Properties of Bearings with Moving Segments (Dynamische Eigenschaften von Gleitlagern mit beweglichen Segmenten)

H. Springer

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 177-184 (1980) 9 figs, 11 refs

(In German)

Key Words: Bearings, Moving loads

A simple method for the determination of the properties of a bearing with movable segments is presented which is based on polar plots of the four deflection frequency curves in a complex plane.

81-1891

Transient Dynamic Analysis of High-Speed Lightly Loaded Cylindrical Roller Bearings. 1: Analysis

T.F. Conry

Univ. of Illinois, Urbana-Champaign, IL, Rept. No. NASA-CR-3334, 83 pp (Jan 1981)
N81-16471

Key Words: Bearings, Roller bearings, Computer programs

The governing differential equations of motion for a high speed cylindrical roller bearing are developed under the assumptions that the bearing is isothermal and that the roller tilt and skew are very small. Two sets of differential equations are presented: the first which deals with planar motion of the roller bearing system; and the second which includes the effect of roller skewing. The equations as presented are in a format for programming on a digital computer.

81-1892

Rotor-Bearing Dynamics Technology Design Guide. Part VIII. A Computerized Data Retrieval System for Fluid Film Bearings

C.H.T. Pan, B.F. Geren, J.A. Bartlett, and S. Fiedler
Shaker Research Corp., Ballston Lake, NY, Rept. No. SRC-79-TR-46, AFAPL-TR-78-6-PT-8, 250 pp (Oct 1980)
AD-A094-087

Key Words: Rotors, Bearings, Fluid film bearings, Data processing, Design techniques

This report describes a computerized data storage retrieval system for the static and dynamic characteristics of fluid film bearings. The procedure combines asymptotic power law extrapolation outside the stored data range with smooth interpolation within the data table. Thirty-one data tables have been prepared and installed in the system. The procedure allows addition of new data tables in the future. The retrieval software allows the user to list the data content in either the dimensional or the dimensionless form or to generate data lines in the sequence and format directly usable as input to the rotordynamics software described. Inertia, compliance and damping effects of the pedestal can be included in the retrieval dynamic characteristics of each bearing.

81-1893

Rotor-Bearing Dynamics Technology Design Guide. Part VI. Status of Gas Bearing Technology Applicable to Aero Propulsion Machinery

C.H.T. Pan
Shaker Research Corp., Ballston Lake, NY, Rept. No. SRC-80-TR-57, AFAPL-TR-78-6-PT-6, 107 pp (Oct 1980)
AD-A094 167

Key Words: Rotors, Bearings, Design techniques, Whirling, Turbomachinery

This report reviews gas lubrication technology as applicable to the support of aero propulsion equipment. It contains a historical sketch of the evolution of the field, a review of relevant fundamentals, a discussion of the whirl stability phenomena, the design of thrust bearings for turbomachines, a brief report on the current state of materials development, and a general review of gas lubricated compliant bearings.

GEARS

81-1894

Vibrations of Involute Teeth Gear Drives (Schwingungserscheinungen in evolentenverzahnten Stirnradgetrieben)

N. Eicher and W. Stühler
Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 67-77 (1980) 8 figs, 4 refs
(In German)

Key Words: Gears, Gear teeth

The vibration of gear drive system is analyzed taking into consideration teeth backlash. Two models were investigated. The first involves the approximation of the backlash function by means of an analytic expression; the other an investigation of an exact backlash function. The stability and amplitude charts for both models were calculated, and the stability of trivial and periodic solutions was investigated. In the second case an impact law was taken into consideration and formulas for the loss factor were derived.

FASTENERS

(Also see No. 1991)

81-1895

Analysis of Plane Connecting Rod Mechanisms Considering the Play in the Swivel Joints (Analyse ebener Koppelgetriebe unter Berücksichtigung des Spiels in Drehgelenken)

C. Hammerschmidt and H. Strumpfel

Technische Hochschule Karl-Marx-Stadt, Germany, Maschinenbautechnik, 30 (3), pp 123-126 (1981) 4 figs, 10 refs
(In German)

Key Words: Joints (junctions), Clearance effects, Friction, Lubrication

The dynamic model of swivel joints affected with play is improved by including friction and damping. The effect of lubricant and the elastic properties of joint elements are considered in the Lagrange's equations of mixed type by characteristics dependent upon parameters. Experimental studies show that the assumptions were permissible.

VALVES

81-1896
Influence of Eccentric Valves on the Vibration of Fluid Conveying Pipes
G. Silva
Dept. of Materials Engrg., Univ. of Illinois, Chicago, IL 50580, Nucl. Engrg. Des., 64 (1), pp 129-134 (Mar 1981) 5 figs, 13 refs

Key Words: Valves, Pipes (tubes), Fluid-induced excitation, Rotatory inertia effects, Translational inertia effects

The dynamic stability of motion of fluid conveying pipes has been the subject of numerous studies. Theoretical interest was stimulated by the non-conservativeness of these systems. Design requirements for pipelines and nuclear related systems provided the additional impetus. Recently, the assessment of the probable influence that large, rigid valves frequently encountered on piping systems might have on the behavior of the overall system was required. In spite of the above mentioned wealth of literature, a great paucity of informa-tion was found on the influence of lumped masses. Consideration of rotatory inertia is apparently non-available. The motivation and contents of the present study stem from these facts.

SEALS

81-1897
Thermoelastic and Dynamic Phenomena in Seals
J.-T. Wu and R.A. Burton
Dept. of Mech. Engrg. and Astronautical Sciences, Northwestern Univ., Evanston, IL, J. Lubric. Tech., Trans. ASME, 103 (2), pp 253-260 (Apr 1981) 7 figs, 13 refs

Key Words: Seals, Thermoelasticity, Geometric effects, Dynamic response

An analysis of a seal model is made where the rotating element has both fixed tilt and two-lobe waviness. The stator is assumed to be gimbal mounted and to have inertial mass. Hydrodynamic lubrication is assumed, following the short bearing or narrow seal model. Conditions are examined where the stator precesses in synchronism with the rotor rotation. Particular interest is given to operating conditions where such behavior appears to degenerate. The objective of this study is to explain a coupled, inertial/thermoelastic phenomenon observed in experiments performed by Benerjee.

STRUCTURAL COMPONENTS

CABLES

81-1898
The Natural Frequencies and Mode Shapes of Cables with Attached Masses
S.S. Sergev and W.D. Iwan
Naval Construction Battalion Center, Port Hueneme, CA, ASME Rept. No. 81-Pet-10

Key Words: Cables (ropes), Natural frequencies, Mode shapes

An algorithm has been developed to calculate mode shapes and natural frequencies of taut cables with attached masses. The transcendental equations of motion are solved by an iterative technique allowing accurate calculation of extremely high mode numbers.

BEAMS

(Also see No. 1954)

81-1899
A New Rectangular Beam Theory
M. Levinson

Dept. of Mech. Engrg., Univ. of Maine, Orono, ME 04469, J. Sound Vib., 74 (1), pp 81-87 (Jan 8, 1981) 2 figs, 11 refs

Key Words: Beams, Rectangular beams, Timoshenko theory

A new theory for beams of rectangular cross-section which includes warping of the cross-sections is presented. By satisfying the shear-free conditions on the lateral surfaces of the beam a pair of coupled equations of motion are obtained such that no arbitrary shear coefficient is required. It is shown that the uncoupled equation for the transverse displacement is the same as the corresponding equation in Timoshenko beam theory provided that for the Timoshenko equation the shear coefficient is taken to be 5/6; this value lies within the range of values, 0·822 - 0·870, appearing in the literature for the beam of rectangular cross-section. Results for two typical static examples are given for both the new theory and Timoshenko beam theory. These results are compared with the solutions of the comparable problems in the linear theory of elasticity.

81-1900

Optimal Design of Rigid-Plastic Simply Supported Beams under Impulsive Loading

Ü. Lepik

Univ. of Tartu, Estonian S.S.R., U.S.S.R., Intl. J. Solids Struc., 17 (6), pp 617-629 (1981) 6 figs, 1 table, 4 refs

Key Words: Beams, Pulse excitation, Optimum design

Optimal design of a rigid-plastic stepped beam is discussed. Such beam dimensions are sought on which the beam of constant volume attains a minimum local or mean deflection. The beam is subjected to a constant initial velocity field. An exact solution to the problem is found and compared with four types of mode form solutions. The error made by using the mode form solutions is estimated. Some suggestions for an optimal design beam are made.

81-1901

Critical Damping in Certain Linear Continuous Dynamic Systems

D.E. Beskos and B.A. Boley

Dept. of Civil and Mineral Engrg., Univ. of Minnesota, Minneapolis, MN 55455, Intl. J. Solids Struc., 17 (6), pp 575-588 (1981) 7 figs, 11 refs

Key Words: Beams, Critical damping, Dynamic stiffness, Influence coefficient method

Free damped vibrations of linear elastic structures composed of uniform beam elements with a continuous distribution of mass are studied. Axial, torsional and flexural vibrations are considered. The amount of damping, which can be either internal or external viscous type, varies among the various beam elements of the structure resulting in many critical damping possibilities. A general method is developed which, with the aid of dynamic stiffness influence coefficients defined for every element, determines the critical damping surfaces of the system. These surfaces represent the loci of combinations of amounts of damping leading to critically damped motion and thus separating regions of partial or complete underdamping from those of overdamping.

81-1902

The Frequency Criterion for Thermally Induced Vibrations in Elastic Beams

F.P.J. Rimrott

Dept. of Mech. Engrg., Univ. of Toronto, Toronto, Ontario, Canada M5S 1A4, Ing. Arch., 50 (4), pp 281-287 (1981) 3 figs, 9 refs

Key Words: Beams, Thermal excitation, Flutter

Thermally induced vibration in elastic beams, also known as thermal flutter, has not yet found a satisfactory treatment. The sheer weight of complications has so far rendered, and may indeed permanently render, a unified treatment impossible. In the present paper a frequency criterion is established which essentially defines the strength of the thermal excitation. Since damping is inevitably present, the thermal excitation must be large enough to overcome damping. After introducing a thermal time constant it is shown that at a critical frequency, the thermal excitation reaches a maximum. For practical cases, this critical frequency is very small, as typical structural frequencies go. Thus only systems with very low eigenfrequencies can be expected to tend to flutter thermally.

81-1903

Free Vibration of Thin Walled Open Section Beams with Constrained Damping Treatment

S. Narayanan and A.K. Mallik

Dept. of Aeronautical Engrg., Indian Inst. of Tech., Kanpur-208016, India, J. Sound Vib., 74 (3), pp 429-439 (Feb 8, 1981) 3 figs, 1 table, 10 refs

Key Words: Beams, Stiffened structures, Constrained structures, Flexural vibration, Torsional vibration, Coupled response, Damping effects

Free vibration characteristics of a thin walled, open cross-section beam, with constrained damping layers at the flanges, are investigated. Both uncoupled transverse vibration and the coupled bending-torsion oscillations of a beam of a top-hat section, are considered. Numerical results are presented for natural frequencies and modal loss factors in the first two modes of simply supported and clamped-clamped beams. For the uncoupled mode the constrained damping treatment is more effective than an unconstrained one, but for the coupled mode the effect is just the opposite.

81-1904

Contribution to Numerical Computation of Lateral Vibration of Beams

I. Porat

Faculty of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Sound Vib., 74 (2), pp 175-185 (Jan 22, 1981) 3 figs, 4 tables, 6 refs

Key Words: Beams, Natural frequencies, Lateral vibration

Two improved methods were developed for numerical computation of natural frequencies of lateral vibration of a non-uniform beam under different boundary conditions. The first method is a transfer matrix (Holzer) method which is a simplification of the conventional Myklestad method, and more accurate by one order of magnitude. The second method is a difference equation method, which is useful when there are complicated boundary conditions; in some cases it too is more accurate (again by one order of magnitude) than its conventional counterpart. Unlike their conventional counterparts, which lack specific regularities with regard to convergence and accuracy, the proposed new methods converge as the relevant numbers of elements squared, and are insensitive to boundary conditions.

81-1905

Vibrations of a Beam Fixed at One End and Carrying a Guided Mass at the Other

P.A.A. Laura and P.L. Vernière De Irassar

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, 811, Argentina, Appl. Acoust., 14 (2), pp 93-99 (Mar-Apr 1981) 4 figs, 1 table, 3 refs

Key Words: Beams, Natural frequencies, Mode shapes

This paper presents an exact solution of the title problem, using classical beam thoery. It is also assumec that the tip mass is guided in such a manner that the end of the beam does not rotate. Frequency coefficients and modal shapes are determined for a wide range of the governing mechanical parameters.

81-1906

Dynamic Analysis of a Beam under a Moving Force: A Double Laplace Transform Solution

T.R. Hamada

Dept. of Mech. Engrg., Sophia Univ., Tokyo, Japan, J. Sound Vib., 74 (2), pp 221-233 (Jan 22, 1981) 1 fig, 3 tables, 8 refs

Key Words: Beams, Moving loads, Bernoulli theory, Laplace transformation

The response problem of a simply supported and damped Bernoulli-Euler uniform beam of finite length traversed by a constant force moving at a uniform speed is solved by applying the double Laplace transformation with respect both to time and to the length co-ordinate along the beam. The sum of the Fourier series is obtained which represents the forced vibration part of the transient response in closed form. The solution is effective for computing beam stresses. It is also shown that the forced vibration part can be expanded in a double power series, and that the coefficients of the series at the point of application of the moving force can be readily obtained by making use of Bernoulli polynomials. Simple approximate formulae obtained from the series are used to compute the forced vibration parts of the deflection and the beam stresses at the mid-span of the beam when a moving load is exactly at the mid-point of the beam, and their truncation errors are calculated.

81-1907

Analytical/Experimental Correlation of a Nonlinear System Subjected to a Dynamic Load

J.C. Anderson and S.F. Masri

Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA 90007, J. Pressure Vessel Tech., Trans. ASME, 103 (1), pp 94-103 (Feb 1981) 12 figs, 3 tables, 7 refs

Key Words: Nonlinear systems, Piping systems, Beams, Cantilever beams

Analytical and experimental studies of the dynamic response of a system with geometric and material nonlinearity are described. The dynamic excitation consists of sinusoidal and impulsive base acceleration. The analytical studies are

performed by transforming the continuous system to an equivalent single-degree-of-freedom system and using numerical techniques to solve the resulting equation of motion. Experimental studies are conducted and responses are measured on the same dynamic systems. Critical comparisons are made between the calculated and measured responses.

81-1908

Dynamic Response of a Cantilever Pile to Vortex Shedding in Regular Waves

M.F. Zedan, J.Y. Young, H.J. Salane, and F.J. Fischer

Brown & Root, Inc., Houston, TX 77001, J. Engrg. Resources Tech., Trans. ASME, 103 (1), pp 32-40 (Mar 1981) 9 figs, 4 tables, 12 refs

Key Words: Pile structures, Cantilever beams, Off-shore structures, Water waves, Vortex shedding

An experimental investigation of cantilever pile dynamics in response to wave excitation under vortex-shedding "lock-in" conditions is summarized. The study was carried out in regular waves for two conditions of wave length in relation to water depth. Pile response was measured in terms of top accelerations and bottom strains in both the in-line and transverse directions. Vortex-shedding lock-in is shown to produce substantial dynamic amplification of deflection not only in the transverse direction, but also in the in-line direction.

81-1909

Buckling and Vibration of Periodic Lattice Structures

M.S. Anderson

NASA Langley Res. Ctr., Hampton, VA, The 1980 Large Space Systems Technol., Vol. 2, pp 35-44 (Feb 1981)

N81-19199

Key Words: Grids (beam grids), Antennas, Periodic structures, Cable-stiffened structures, Finite element technique

Lattice booms and platforms composed of flexible members or large diameter rings which may be stiffened by cables in order to support membrane-like antennas or reflector surfaces are the main components of some large space structures. The nature of these structures, repetitive geometry with few different members, makes possible relatively simple solutions for buckling and vibration of a certain class of these structures.

81-1910

Natural Frequencies of Curved Girders

C.H. Yoo and J.P. Fehrenbach

Marquette Univ., 1515 W. Wisconsin Ave., Milwaukee, WI 53233, ASCE J. Engrg. Mechanics Div., 107 (2), pp 339-354 (Apr 1981) 8 figs, 3 tables, 28 refs

Key Words: Curved beams, Girders, Natural frequencies, Rotatory inertia effects, Stiffness coefficients, Variable cross section

A general finite element displacement formulation is presented to determine the natural frequencies of spatial thin-walled curved girders including the warping contribution. Also included are the rotatory inertia effects with respect to flexure and torsion, and the effects of antisymmetry of cross section (found to be significant). The stiffness and inertia properties of the finite element are obtained using the solutions of homogeneous differential equations governing the static problem as deformation modes. The obtained element relationships were programmed for use in digital computers, and a few example problems were analyzed. Some charts are given to expedite the determination of natural frequencies of horizontally curved girders.

CYLINDERS

(Also see Nos. 1836, 1886)

81-1911

On the Added Mass and Radiation Damping of Rod Bundles Oscillating in Compressible Fluids

W.H. Lin and S.S. Chen

Components Tech. Div., Argonne Natl. Lab., Argonne, IL 60439, J. Sound Vib., 74 (3), pp 441-453 (Feb 8, 1981) 6 figs, 20 refs

Key Words: Cylinders, Circular cylinders, Damping coefficients, Viscous damping

A theoretical analysis as well as numerical results for the added mass and radiation damping coefficients of a group of two-dimensional circular cylinders oscillating harmonically in an infinite compressible fluid is presented. The fluid reaction force on these vibrating cylinders is obtained by solving the two-dimensional acoustic wave equation with Neumann conditions on the cylinders and the radiation condition at infinity. Numerical results show that when the acoustic wavelength is large compared with the cylinder radius, the added mass predominates over the radiation damping, and both are independent of the dimensionless wavenumber. When the acoustic wavelength is small compared with the cylinder radius, the radiation damping predominates over the added mass, and both are small.

81-1912

Aspects of Hydrodynamic Loading in Design of Production Risers

A.E. Loken, O.P. Torset, S. Mathiassen, and T. Arnesen

J. Pet. Tech., 32 (5), pp 881-890 (May 1980) 19 figs, 3 tables, 13 refs

Key Words: Marine risers, Hydrodynamic excitation, Fluid-induced excitation, Experimental test data

An experimental program undertaken to understand better the hydrodynamic loading of multitube production risers is described. Test results and a generalization for engineering applications are given. Sample design calculations are performed.

FRAMES AND ARCHES

(Also see Nos. 1990, 2044)

81-1913

Dynamic Response and Stability of Rigid Frames Subjected to Time-Dependent Axial Forces

C.H. Tay

Ph.D. Thesis, Univ. of Wisconsin, 186 pp (1980)
UM 8128211

Key Words: Frames, Rigid frames, Time dependent excitation, Axial excitation, Natural frequencies, Lumped parameter method, Consistent mass method, Continuous parameter method, Computer programs

The dynamic response of rigid frames when subjected to time-dependent axial forces in the constituent members is obtained by treating the axial forces as piecewise time-dependent. Computer programs are written for each of the methods of determining natural frequency. The effects of constant axial forces on the natural frequencies of three structures are studied.

81-1914

Dynamic Analysis of Frames by a Two-Level Finite Element Method

Y.T. Leung and Y.K. Cheung

Dept. of Civil Engrg., Univ. of Hong Kong, Hong Kong, J. Sound Vib., 74 (1), pp 1-9 (Jan 8, 1981) 5 figs, 4 tables, 9 refs

Key Words: Frames, Finite element technique

A two-level finite elemer.. technique of constructing a frame super-element is introduced to reduce the computational efforts for solving large scale frame problems. The ordinary finite element method is used first to yield matrices for the beam members. Then the nodal displacements of all the nodes are related to those of a small number of selected joints (master nodes) in the frame by means of global finite element interpolating functions. Thus the order of the overall matrices is greatly reduced and the frame may be considered as a super-element to be connected to other elements by means of the master nodes.

81-1915

Simple Nonlinear Seismic Analysis of R/C Structures

M. Saiidi and M.A. Sozen

Dept. of Civil Engrg., Univ. of Nevada, Reno, NV 89557, ASCE J. Struc. Div., 107 (5), pp 937-952 (May 1981) 11 figs, 2 tables, 12 refs

Key Words: Frames, Reinforced concrete, Seismic analysis

A simple analytical model is developed for the calculation of the seismic displacement history response of reinforced concrete frame and frame-wall structures. A structure is idealized as a "single-degree" system consisting of a mass mounted on a rigid bar connected to the ground by a hinge and a nonlinear rotational spring. The primary force-deformation relationship for the spring is obtained by a static analysis of the multistory structure. To account for stiffness changes during an earthquake, a simple hysteresis model comprising only four rules is developed. The model is examined for eight small-scale ten-story reinforced concrete test structures, and the analytical results are compared with the measured response histories.

81-1916

Seismic Study of Industrial Steel Storage Racks

C.K. Chen, R.E. Scholl, and J.A. Blume

URS/John A. Blume and Assoc., San Francisco, CA, Rept. No. NSF/RA-800279, 552 pp (June 1980) PB81-142101

Key Words: Racks, Seismic design, Seismic response

Development of criteria and procedures for the seismic design of industrial steel storage racks is reported. The

investigation focused on mathematical models for predicting earthquake response of racks and obtaining experimental data to quantify limit behavior of racks under earthquake conditions. Methodology consisted of subjecting four types of full-scale storage racks to simulated earthquake motions.

MEMBRANES, FILMS, AND WEBS

81-1917
Free Vibration of Regular Polygonal Plates with Simply Supported Edges

T. Irie, G. Yamada, and K. Umesato
Dept. of Mech. Engrg., Faculty of Engrg., Hokkaido Univ., Sapporo 060 Japan, J. Acoust. Soc. Amer., 69 (5), pp 1330-1336 (May 1981) 4 figs, 5 tables, 13 refs

Key Words: Membranes (structural members), Plates, Natural frequencies, Mode shapes

The free vibration of regular polygonal plates with simply supported edges is studied by the dynamical analogy with membranes. A regular polygonal membrane is formed on a rectangular membrane by fixing several segments. With the reaction forces acting on all edges of an actual polygonal membrane regarded as unknown harmonic loads, the stationary response of the membrane to these loads is expressed by the eigenfunctions of the extended rectangular membrane without internal supports. The force distributions along the edges are expanded into Fourier sine series with unknown coefficients, and the homogeneous equations for the coefficients are derived by restraint conditions on the edges. The natural frequencies and the mode shapes of the actual membrane are determined by calculating the eigenvalues and eigenvectors of the equations. The method is applied to an equilateral triangular through a regular decagonal membrane, the natural frequencies and mode shapes are calculated numerically and the effect of the shape of membrane is discussed. The numerical values obtained for polygonal membranes are immediately converted into those of simply supported polygonal plates.

PANELS

81-1918
Point-Force Excited Vibrations of a Thin, Infinite Panel Separating a Fluid Layer from a Fluid Half-Space

V. Schroter and F.J. Fahy
Inst. Sound Vib. Res., Univ. of Southampton, Southampton S09 4NH, UK, J. Sound Vib., 74 (4), pp 465-476 (Feb 22, 1981) 3 figs, 20 refs

Key Words: Panels, Point source excitation, Harmonic excitation, Acoustic response, Interaction: structure-fluid

A coupled system consisting of a thin, infinite panel separating a fluid layer and a fluid half-space is considered. The response of the panel when driven by a point harmonic force is evaluated by using Hankel transform analysis in conjunction with complex variable integration techniques. The emphasis is placed on frequencies well below the panel critical frequency, on dense fluid loading, and on the condition of shallow layer depth. The analysis yields the free propagation wave numbers of the coupled system: below the critical frequency, all but one are complex. From the solutions of the response integrals, the panel flexural velocity, the acoustic pressures, the power transmitted into the structure and into the fluid layer, and the radiated acoustic power, are obtained.

81-1919
The Oblique Incidence Measurement of Transmission Loss by an Impulse Method

J.C. Davies and B.M. Gibbs
Dept. of Bldg. Engrg., Univ. of Liverpool, Liverpool L69 3BX, UK, J. Sound Vib., 74 (3), pp 381-393 (Feb 8, 1981) 13 figs, 14 refs

Key Words: Panels, Sound transmission, Pulse excitation

The oblique incidence transmission loss of a free standing panel has been determined experimentally with the use of short duration impulsive signals. The geometry of the source, panel and receiver is such that the direct signal can be isolated and, on subsequent analysis, the infinite panel response obtained. Agreement with mass law is good and the angular and spectral variation of coincidence is clearly seen. Closer inspection of the time history of the transmitted waves shows a signal which arrives after the direct signal has effectively finished and before the arrival of scattered waves from the edge of the plate. Frequency analysis of this component reveals a coincidence type dip which is independent of angle and frequency.

81-1920
Radiation from Modes of a Rectangular Panel into a Coupled Fluid Layer

V. Schroter and F.J. Fahy

Inst. Sound Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 74 (4), pp 575-587 (Feb 22, 1981) 6 figs, 9 refs

Key Words: Panels, Rectangular panels, Sound waves, Vibrating structures

Modal radiation efficiencies are evaluated for a rectangular panel which is simply supported in an infinite baffle and coupled to a fluid layer. The analysis is based on the calculation of the acoustic power radiated into the layer by the panel vibrating in one of its in vacuo natural modes. At low frequencies, the efficiency is inversely proportional to the layer depth; at high frequencies, it exhibits a complex, multiple peak characteristic, associated with the acoustic field of the layer. Comparison with the modal radiation efficiencies of a panel coupled to a fluid half-space shows a similar dependence on mode order and panel dimensions.

81-1921

Predictive Dynamic Response of Panel Type Structures under Earthquakes

J.P. Kollegger and J.G. Bouwkamp

Earthquake Engrg. Res. Ctr., Univ. of California at Berkeley, Rept. No. UCB/EERC-80/31, NSF/RA-800296, 70 pp (Oct 1980)

PB81-152316

Key Words: Buildings, Multistory buildings, Panels, Earthquake response, Translational response, Rotational response

The potential coupling of translational and rotational motions of prefabricated panel systems under earthquake ground excitation is studied for several 12-story-high apartment buildings. Placement of apartments along the short end of these buildings and limiting the number of apartments along the long sides resulted in twelve different floor plans. Resonance and modal analyses were performed indicating considerable coupling of the longitudinal translational and torsional modal components. A hypothesis regarding the anticipated behavior under earthquake excitation was developed and successfully tested against the analytical predicted structural response.

PLATES

(Also see Nos. 1917, 1984, 2037, 2038, 2039, 2040, 2041)

81-1922

Natural Frequencies of Orthotropic Rectangular Plates with Stepped Thickness

T. Sakata

Dept. of Mech. Engrg., Chubu Inst. of Tech., Kasugai, Nagoya-sub., Japan 487, J. Sound Vib., 74 (1), pp 73-79 (Jan 8, 1981) 4 figs, 1 table, 8 refs

Key Words: Plates, Rectangular plates, Variable cross section, Orthotropism, Natural frequencies, Fundamental frequency

It is shown how an approximate formula is derived for estimating a natural frequency of an orthotropic rectangular plate with stepped thickness by using several natural frequencies of the corresponding isotropic plate reduced from the orthotropic one. To justify the method, an orthotropic two-part rectangular plate with simply supported sides is discussed, and an approximate formula is proposed for estimating the fundamental natural frequency.

81-1923

Receptances of Non-Proportionally and Continuously Damped Plates - Equivalent Dampers Method

H.N. Özgüven and A. Cowley

Dept. of Mech. Engrg., Middle East Tech. Univ., Ankara, Turkey, J. Sound Vib., 76 (1), pp 23-41 (May 8, 1981) 8 figs, 3 tables, 23 refs

Key Words: Plates, Damped structures, Layered materials, Transverse vibration, Harmonic excitation

A method for the dynamic analysis of continuously and non-proportionally damped plates is discussed. The method is quite general and suitable for various damping treatments, such as in multilayer plates with damping layers. The transverse vibrations of partially coated plates under harmonic excitation are analyzed by the proposed method. The results of the undamped modal analysis made by classical finite element methods are used in the suggested lumped parameter analysis. The receptance matrices of coated plates are computed at undamped natural frequencies. Computational results are verified by comparison with experimental values for partially and fully coated rectangular plates.

81-1924

Simplified Method for Solving Problems of Vibrating Plates of Doubly Connected Arbitrary Shape, Part 1: Derivation of the Frequency Equation

K. Nagaya

Dept. of Mech. Engrg., Gunma Univ., Kiryu, Gunma, Japan, J. Sound Vib., 74 (4), pp 543-551 (Feb 22, 1981) 1 fig, 1 table, 18 refs

Key Words: Plates, Vibrating structures, Flexural vibration, Natural frequencies, Mode shapes, Boundary condition effects, Fourier analysis

A simplified approximate method for solving problems of vibrating plates of doubly connected arbitrary shapes is presented. In the analysis, an arbitrarily shaped boundary is divided into small segments, and general transformed expressions for the bending slope, the bending moment and the shearing force of a segment are given, under the assumption that the angle between the normal to the segment and the reference axis is constant. The boundary conditions along the outer and the inner edges are satisfied by means of the Fourier expansion collocation method. The equation for finding the eigenfrequencies and mode shapes is obtained for arbitrarily shaped boundaries.

81-1925

Simplified Method for Solving Problems of Vibrating Plates of Doubly Connected Arbitrary Shape, Part II: Applications and Experiments

K. Nagaya
Dept. of Mech. Engrg., Gunma Univ., Kiryu, Gunma, Japan, J. Sound Vib., 74 (4), pp 553-564 (Feb 22, 1981) 7 figs, 11 tables, 17 refs

Key Words: Plates, Vibrating structures, Natural frequencies, Mode shapes, Boundary condition effects, Experimental test data

The eigenfrequencies of ring-shaped polygonal plates, ring-shaped elliptical plates, rectangular plates with elliptical inner boundaries and circular plates with elliptical inner boundaries are obtained. The method developed by the author in the companion paper (Part I) is applied for finding the eigenfrequencies. To verify the present results, experimental tests have also been carried out for some important cases.

81-1926

Experimental Investigation of Free Vibrations of Clamped Sector Plates

K. Maruyama and O. Ichinomiya
Dept. of Mech. Engrg., Hokkaido Inst. of Tech., 419-2, Teine-Maeda, Nishi-ku, Sapporo, 061-24, Japan, J. Sound Vib., 74 (4), pp 565-573 (Feb 22, 1981) 6 figs, 8 refs

Key Words: Plates, Wedges, Rings, Natural frequencies, Mode shapes, Flexural vibration, Experimental test data, Holographic techniques, Interferometric techniques

The real time technique of time-averaged holographic interferometry is applied to determine the natural frequencies and the corresponding mode shapes for the transverse vibrations of clamped wedge-shaped and ring-shaped sector plates. Over 200 resonant modes are obtained for wedge-shaped sector plates and over 170 for ring-shaped sector plates. The natural frequencies obtained are expressed in terms of a dimensionless frequency parameter, and the results are shown graphically as a function of the sector angle for the wedge-shaped plates and of the radii ratio for the ring-shaped sector plates, respectively.

81-1927

Refined Theory for Flexural Motions of Isotropic Elastic Plates

G.Z. Voyiadjis and M.H. Baluch
Dept. of Civil Engrg., Louisiana State Univ., Baton Rouge, LA 70803, J. Sound Vib., 76 (1), pp 57-64 (May 8, 1981) 1 table, 14 refs

Key Words: Plates, Flexural vibration, Rotatory inertia effects, Transverse shear deformation effects

A technical theory for the flexural motions of isotropic elastic plates has been developed, taking into account the influence of transverse normal strain and transverse normal stress, together with rotatory inertia and transverse shear. The theory is tested by studying the classical wave propagation problem.

81-1928

Dynamic Analysis of Unbalanced Anisotropic Sandwich Plates

I.M. Ibrahim, A. Farah, and M.N.F. Rizk
Faculty of Engrg., Univ. of El-Zagazig, Egypt, ASCE J. Engrg. Mechanics Div., 107 (2), pp 405-418 (Apr 1981) 7 figs, 4 tables, 5 refs

Key Words: Plates, Sandwich structures, Orthotropism, Core-containing structures, Stiffness methods

The modified stiffness method of unbalanced anisotropic sandwich plates is extended and applied to the dynamic analysis of sandwich plates consisting of an orthotropic core and two equal thickness anisotropic face plates. The formulation allows for the dynamic analysis of certain types of sandwich plates that were not amenable to rigorous solutions due to the existence of anisotropic coupling stiffnesses, such as those with inbalanced angle-ply faces. The method is independent of the boundary conditions and can be

combined with a variety of analysis techniques. Using a series solution, results are generated for simply-supported sandwich plates with unbalanced cross-ply and angle-ply face plates. In addition, the effect of coupling in the static and dynamic responses is presented.

81-1929

Analysis of Layered Composite Plates Accounting for Large Deflections and Transverse Shear Strains

J.N. Reddy

Dept. of Engrg. Sci. and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Rept. No. TR-21, 48 pp (May 1981) 16 figs, 9 tables, 100 refs

Key Words: Plates, Rectangular plates, Composite structures, Layered materials, Large amplitudes, Transverse shear deformation effects, Rotatory inertia effects, Finite element technique

A finite-element analysis is presented for large-deflection bending and large-amplitude free vibration of rectangular plates of cross-ply and angle-ply construction under various edge conditions and loadings. The finite element employed in the present study accounts for transverse shear and rotatory inertia (in the Reissner-Mindlin sense), and large rotations (in the von Karman sense). The finite element solutions are found to agree very closely with results available in the literature.

81-1930

Mutual Acoustic Impedance of Circular Membranes and Plates with Bessel Axially-Symmetric Vibration Velocity Distributions

W. Rdzanek

Theoretical Physics Dept., Higher Pedagogical School, 65-069 Zielona Góra, Plac Slowiański 6, Poland, Arch. Acoust., 3 (3), pp 237-250 (1980) 5 figs, 1 table, 11 refs

Key Words: Vibration analysis, Acoustic impedance, Circular membranes, Circular plates

The mutual impedance of circular membranes and circular plates clamped at the circumference is analyzed. It was assumed that a Bessel axially-symmetric vibration velocity distribution was predetermined on the surface of the sources, and that the sources were placed in a rigid planar baffle. The impedance was calculated by a method based on a Fourier representation of the acoustic pressure. In view of the axially-symmetric vibration velocity distribution, the acoustic pressure and the subsequent formulae for the mutual impedance are given in the Hankel representation. As a result, the mutual impedance can be expressed in the form of a single integral. Practically useful formulae are derived for specific cases. Results of the calculation are shown graphically.

81-1931

Natural Frequencies of Rotating Bladed Disks (Eigenschwingungen rotierender, beschaufelter Scheiben)

H. Irretier

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 167-176 (1980) 12 figs, 8 refs

(In German)

Key Words: Disks, Blades, Natural frequencies, Mode shapes, Mathematical models

A mathematical model for the determination of natural frequencies of a disk with a large number of blades is presented. It includes the bending and membrane vibrations of the disk, and bending and torsional vibrations of the blade. In addition, the effects of variable thickness, centrifugal force and the location of blades on the disk are also taken into consideration.

81-1932

Vibrations of Circular Plates with Variable Profile

R. Gelos, G.M. Ficcadenti, R.O. Grossi, and P.A.A. Laura

Inst. of Appl. Mechanics, Puerto Belgrano Naval Base, 8111 Argentina, J. Acoust. Soc. Amer., 69 (5), pp 1326-1329 (May 1981) 3 figs, 4 tables, 5 refs

Key Words: Plates, Circular plates, Variable cross section, Flexural vibration

Galerkin's variational approach is invoked in analyzing transverse vibrations of circular plates where the thickness varies according to the functional relation $h(r) = h_0[1 + \gamma(r/a)^n]$ where n is an integer. The displacement function is approximated in terms of simple polynomials which identically satisfy the boundary conditions. The two lowest frequency coefficients of axisymmetric modes are determined for several combinations of the governing mechanical parameters.

81-1933

On the Non-Linear Vibration of Circular Plates of Variable Thickness Elastically Restrained Along the Edges

M.M. Banerjee, P.K. Sarker, and P. Kapoor
Dept. of Physics, A.C. College, Jalpaiguri 735 101, West Bengal, India, J. Sound Vib., 74 (4), pp 589-596 (Feb 22, 1981) 1 fig, 3 tables, 17 refs

Key Words: Plates, Circular plates, Variable cross section, Nonlinear vibrations, Vibration frequencies

Berger's technique of neglecting the second strain invariant in the middle plane of the plate is used in an investigation of the effect of non-linearity on the frequency of a vibrating circular plate of variable thickness which is elastically restrained along its circumference. A simple polynomial expression for the deflection function and a Galerkin method are used in the analysis.

81-1934

Behavior of Viscoplastic Circular Plates under Gaussian Impulse

J.B. Kennedy and K.J. Iyengar
Dept. of Civil Engrg., Univ. of Windsor, Ontario, Canada, Nucl. Engrg. Des., 64 (1), pp 117-128 (Mar 1981) 12 figs, 12 refs

Key Words: Plates, Circular plates, Impact response (mechanical), Normal density functions, Dynamic plasticity

The dynamic plastic behavior of viscoplastic circular plates subjected to impulse loading is presented. The impulse is assumed to impart a transverse axisymmetric velocity with a spatial Gaussian distribution. The combined influence of membrane forces, bending moments and strain-rate sensitivity is considered in predicting the deformation. Numerical results are presented to show this influence on the rate of growth of plastic regimes, the deflection configuration and the total time of response. It is concluded that the spatial distribution of impulse has a considerable effect on the deformation response of the plate, and relatively small effect on the total time of response; furthermore, the simple bending theory is inadequate to reliably predict the response.

81-1935

Large Deflections and Large Amplitude Vibrations of Axisymmetric Circular Plates

J.N. Reddy, C.L. Huang, and I.R. Singh
Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Intl. J. Numer. Methods Engrg., 17 (4), pp 527-541 (Apr 1981) 6 figs, 4 tables, 13 refs

Key Words: Plates, Circular plates, Flexural vibration, Large amplitudes, Transverse shear deformation effects, Finite element technique

This paper is concerned with the conventional and mixed finite element analysis of large deflection bending and free vibration of axisymmetric circular plates including shear deformation. Conventional and mixed finite element formulations are presented. Numerical results are included for isotropic as well as orthotropic, circular and annular plates under various edge conditions and loadings.

81-1936

Rotary Oscillations of a Rigid Disc Inclusion Embedded in an Isotropic Elastic Infinite Space

A.P.S. Selvadurai
Dept. of Civil Engrg., Carleton Univ., Ottawa, Canada KIS 5B6, Intl. J. Solids Struc., 17 (5), pp 493-498 (1981) 4 figs, 20 refs

Key Words: Disks (shapes), Foundations, Elastic half-space, Interaction: soil-structures

The asymmetric problem related to the harmonic oscillations of a rigid circular disc inclusion embedded in bonded contact with an isotropic elastic medium of infinite extent is examined. The analysis of the problem is reduced to the solution of a single Fredholm integral equation of the second kind which is solved in an appropriate manner. The dynamic rotary stifnesses are developed for a range of mass ratios and frequencies of practical interest.

81-1937

On the Behavior of Plates Laminated of Bimodulus Composite Materials

J.N. Reddy and C.W. Bert
Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Dept. of Navy, Office of Naval Res., Rept. No. VPI-E-81-11, OU-AMNE-81-1, 22 pp (Apr 1981) 4 figs, 5 tables, 28 refs

Key Words: Plates, Composite structures, Layered materials, Finite element technique, Natural vibrations, Shear deformation effects, Rotatory inertia effects

An exact and finite-element analysis is used to predict the static bending and natural vibration response of rectangular plates laminated of composite material having different elastic properties depending upon whether the fiber-direction strains are tensile or compressive. The analysis is based on a theory that accounts for anisotropy, bending-stretching coupling, thickness shear deformation, and both coupling inertia and rotatory inertia. The finite element results are found to agree very closely with the exact closed-form solutions in the case of a cross-ply rectangular plate having simply supported edges and subjected to sinusoidally distributed normal-pressure loading or temperature loading.

81-1938

Adding Fatigue Life to Cover Plate Ends

S. Simon and P. Albrecht

Sverdrup & Parcel & Assoc., Silver Spring, MD, ASCE J. Struc. Div., 107 (5), pp 923-936 (May 1981) 5 figs, 8 tables, 8 refs

Key Words: Plates, Bridges, Girders, Fatigue life

A parametric analysis was performed of simple-span and two-span continuous bridge girders with cover plates. The cover plates were either end-bolted or end-welded and ground, with available data suggesting a fatigue resistance corresponding to Category B and C, respectively. All results were compared with conventionally welded cover plates, with ends designed to Category E. End-bolted cover plates need not be extended beyond the theoretical cut-off point because fatigue does not control the design for any loading case. Stress ranges are lower than the fatigue limit, and girders up to 5 percent lighter. When the end weld is ground to a 1:3 taper, fatigue governs the cover plate length for over 2 million cycles, but not for 500,000 cycles. Girders weigh up to 3.7 percent less. The saving in the cost of cover plate material is equal to or greater than the added cost of end-bolting or end-grinding.

SHELLS

81-1939

Dynamic Stresses in Spherical Containments with Pressure Suppression System During Steam Condensation

R. Krieg, B. Göller, and G. Hailfinger

Kernforschungszentrum Karlsruhe GmbH, Institut f. Reaktorentwicklung, Postfach 3640, 7500 Karlsruhe, Fed. Rep. Germany, Nucl. Engr. Des., 64 (2), pp 203-223 (Apr 1981) 4 figs, 1 table, 11 refs

Key Words: Shells, Spherical shells, Containment structures, Nuclear reactor components, Cooling systems

Different physical phenomena which control the structural integrity of the containment shell in case of a postulated failure of the primary coolant system are discussed. Detailed analyses are carried through for the chugging phase, where steam will be blown into the water pool of the pressure suppression system. As reference geometry a German boiling water reactor type 69 is used. The fluid dynamics of the water pool is described by a boundary integral equation method. For the structural dynamics of the thin spherical containment shell analytical solutions of Flugge's shell equations are obtained. The feedback of structural deformations on the fluid-dynamic loadings, i.e., the effect of fluid-structure interaction is considered. It increases the loadings significantly in comparison to calculations without this effect. The steam condensation in the water pool is treated as a parameter.

81-1940

Effect of Elastic End Rings on the Eigenfrequencies of Thin Cylinders

M. El-Raheb and C.D. Babcock, Jr.

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 91103, J. Sound Vib., 74 (1), pp 31-46 (Jan 8, 1981) 10 figs, 1 table, 10 refs

Key Words: Shells, Cylindrical shells, Boundary condition effects, Stiffened shells, Rings, Natural frequencies

The effect of elastic end rings on the eigenfrequencies of thin cylindrical shells is studied by using an exact solution of the linear eigenvalue problem. The out-of-plane and torsional rigidities of the rings are responsible for the overall shell stiffness. Considerable mode interaction exists for modes with low circumferential wave numbers when the mass of the ring is comparable with that of the shell. The hypothetical simply supported and clamped boundary conditions are practically impossible to realize with a finite-mass ring for relatively short and thin shells.

81-1941

Existence of Axisymmetric Modes of Thin Cylindrical Shells with Axial Displacement Restraint

M. El-Raheb

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 91103, J. Sound Vib., 74 (3), pp 419-428 (Feb 8, 1981) 5 figs, 6 refs

Key Words: Shells, Cylindrical shells, Eigenvalue problems, Flexural vibration, Fundamental frequency

A necessary and sufficient condition is derived for the existence of the axisymmetric mode of cylindrical shells with a radial displacement having one half wave along the axis and axial displacement restrained at both ends. The condition is purely geometric and consists of an upper bound on the mean radius to thickness ratio for a given fixed value of the length to mean radius ratio, above which the mode with one half wave in radial displacement along the axis ceases to exist. The proof is based on enforcing two basic lemmas concerned with the simplicity of the eigenvalues of the shell and the uniform ordering of these eigenvalues with the number of nodes of their corresponding radial displacement eigenfunctions.

81-1942

Free Vibration Analysis of Circular Cylindrical Shells

H. Chung

Components Tech. Div., Argonne Natl. Lab., Argonne, IL 60439, J. Sound Vib., 74 (3), pp 331-350 (Feb 8, 1981) 2 figs, 5 tables, 23 refs

Key Words: Shells, Cylindrical shells, Axial vibration, Thermal excitation, Nuclear reactors

A general analytical method is presented for evaluating the free vibration characteristics of a circular cylindrical shell with classical boundary conditions of any type. The solution is obtained through a direct solution procedure in which Sanders' shell equations are used with the axial modal displacements represented as simple Fourier series expressions. Stokes' transformation is exploited to obtain correct series expressions for the derivatives of the Fourier series. An explicit expression of the exact frequency equation can be obtained for any kind of boundary conditions. The accuracy of the method is checked against available data. The method is used to find the modal characteristics of the thermal liner model of the U.S. Fast Test Reactor. Numerical results obtained are compared with finite element method solutions.

81-1943

An Analytical Quasi-Exact Method for Calculating Eigenvibrations of Thin Circular Cylindrical Shells

A. Ludwig and R. Krieg

Kernforschungszentrum Karlsruhe GmbH, Institut f. Reaktorentwicklung, Postfach 3640, 7500 Karlsruhe, Fed. Rep. Germany, J. Sound Vib., 74 (2), pp 155-174 (Jan 22, 1981) 9 figs, 2 tables, 13 refs

Key Words: Shells, Cylindrical shells, Natural frequencies, Nuclear reactors

A method for calculating the eigenfrequencies and corresponding deformation modes of a thin circular cylindrical shell is presented, based on analytical solutions of Flugge's shell theory equations. The partial differential equations are transformed into algebraic equations which can be solved with high accuracy. Consequently, the results can be considered as quasi-exact. Results of the calculations are presented for a shell stiffened at both circular edges. Such boundary conditions are typical of the core barrel of a pressurized water reactor, for instance. Most of the calculated deformation modes show strong gradients of the displacements close to the boundaries.

81-1944

Flow Around Fixed Circular Cylinders: Fluctuating Loads

C. Farell

Anthony Falls Hydr. Lab., Dept. of Civil and Mineral Engrg., Univ. of Minnesota, Minneapolis, MN 55414, ASCE J. Engrg. Mechanics Div., 107 (3), pp 565-588 (June 1981) 2 figs, 1 table, 67 refs

Key Words: Shells, Cylindrical shells, Fluid-induced excitation, Wind-induced excitation, Turbulence

A review is presented of existing experimental information on the flow around, and the fluctuating loads on, fixed circular cylinders in uniform streams, including in particular the effects of free-stream turbulence and surface roughness. Dependent parameters examined are the Strouhal number, the root mean square drag, lift, and pressure coefficients, and the correlations and spectra of the fluctuations. The characterization and definition of the various flow regimes (subcritical, critical, supercritical, and transcritical), and the manner of transition between regimes are analyzed, with due regard to the possible three-dimensional nature of the flow and the effect of the inherent flow unsteadiness.

81-1945

The Effect of Viscosity on Free Oscillations of Fluid-Filled Spherical Shells

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Dept. of Civil Engrg., Texas A&M Univ., College Station, TX 77843, J. Sound Vib., 74 (2), pp 205-220 (Jan 22, 1981) 5 figs, 1 table, 14 refs

Key Words: Shells, Spherical shells, Fluid-filled containers, Viscosity, Viscous damping, Axisymmetric vibrations

In order to clarify the effect of fluid viscosity on the vibrations of elastic shells, the axisymmetric free oscillations of a fluid-filled spherical shell are studied. The dynamic response of the shell is determined by the classical normal mode method, while a boundary layer approximation is employed for the compressible viscous fluid medium. The study shows that the fluid viscosity in general will produce a damping effect on the shell motion. It is also shown that the change on the real and imaginary components of each natural frequency due to viscosity are equal in magnitude but opposite in sign. Therefore, the circular frequency of a vibrating spherical shell will decrease with the increase of viscosity of the contained fluid.

81-1946

Parametric Instabilities of a Liquid Free Surface in a Flexible Container under Vertical Periodic Motion

R.S. Khandelwal and N.C. Nigam

Dept. of Aeronautical Engrg., Indian Inst. of Tech., Kanpur-208016, India, J. Sound Vib., 74 (2), pp 243-249 (Jan 22, 1981) 2 figs, 5 refs

Key Words: Containers, Fluid-filled containers, Flexible foundations, Periodic excitation, Parametric response

Parametric instabilities of the free surface of a liquid in a rectangular container with a flexible base under a vertical periodic excitation are investigated. Bolotin's method is used to determine the regions of dynamic instabilities, with use of the linearized equations of hydrodynamics. Primary and secondary instability regions are determined. It is found that, in general, the presence of a flexible base has the effect of reducing the regions of instability of the free surface of the liquid.

81-1947

Hydroelastic Vibrations in a Rectangular Container

H.F. Bauer

Hochschule der Bundeswehr München, Fachbereich Luft -und Raumfahrttechnik, W. Germany, Intl. J. Solids Struc., 17 (7), pp 639-652 (1981) 7 figs, 28 refs

Key Words: Containers, Fluid-filled containers, Fluid-induced excitation

The interaction of an elastic bottom with the liquid exhibiting a free liquid surface has been investigated for a rectangular container. For this reason the container bottom was considered either as a flexible membrane or as a thin elastic rectangular plate. The hydroelastic problem of a liquid in a rigid rectangular tank in which the free liquid surface was covered by a flexible membrane or a thin elastic plate has also been treated. In both cases the coupled frequencies of the structure-liquid system has been obtained. It was found that even structural modes couple with odd liquid modes and vice versa and that the coupled frequencies exhibit decreased magnitude compared with the uncoupled structural frequencies and increased magnitude compared to the uncoupled liquid frequencies. They decrease with decreasing tension of the membrane or decreasing stiffness of the plate.

81-1948

Three-Directional Fluid Pool Seismic Sloshing Analysis

T.F. Li, C.C. Lin, and C.H. Luk

Stone & Webster Engrg. Corp., Cherry Hill, NJ 08034, J. Pressure Vessel Tech., Trans. ASME, 103 (1), pp 10-15 (Feb 1981) 4 figs, 2 tables, 11 refs

Key Words: Sloshing, Tanks (containers), Seismic excitation

Liquid sloshing in a pool due to three-directional earthquake ground motion is analyzed. The liquid pool is represented by a rigid annular circular cylindrical tank. Analytical and numerical solutions are presented and their limitations are discussed. For a given seismic ground excitation time-history, the free surface and the pressure and velocity fields in the pool are calculated by superposition of modal responses. The results show that container vertical acceleration is of secondary importance in determining the free surface displacement, but has a major effect on the pressure load on the container boundary.

81-1949

A Nonlinear Analysis of Liquid Sloshing in Rigid Containers

Y.K. Lou, T.C. Su, and J.E. Flipse

Ocean Engrg. Program, Texas A&M Univ., College Station, TX, Rept. No. COE-241, TAMU-FE-4084, MA-RD-940-80092, 220 pp (Aug 1980)
PB81-135204

Key Words: Tanks (containers), Containers, Fluid-filled containers, Sloshing, Vibration resonance

Two nonlinear theories have been developed in which the effects of large tank motions on liquid sloshing are properly

accounted for. One theory is applicable for the near resonance oscillations while the other is valid when the tank is oscillating at a frequency away from resonance. In addition to the analytical work, limited experimental studies have also been conducted. Comparisons of the analytical and experimental results are generally very good.

81-1950

Vibration of a Liquid with a Free Surface in a Spinning Spherical Tank

M. El-Raheb and P. Wagner
Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 91103, J. Sound Vib., 76 (1), pp 83-93 (May 8, 1981) 7 figs, 9 refs

Key Words: Tanks (containers), Fluid-filled containers, Rotating structures, Finite element technique

The problem of forced fluid vibrations in a partially filled spinning spherical tank is solved numerically by using the finite element method. The governing equations include Coriolis acceleration and spatially homogeneous vorticity. An exponential instability is detected in the present simulation for fill ratios below 0 5 and centrifugal acceleration to thrust ratios less than 1 7. This fictitious instability appears in the model as a result of the homogeneous vortex assumption since the free slosh equations are neutrally stable in the Liapunov sense.

81-1951

Fluid Mass Matrices for Thin Shell-of-Revolution Tanks

R.E. Ball and R.L. Citerley
Naval Postgraduate School, Monterey, CA 93940, J. Pressure Vessel Tech., Trans. ASME, 102 (4), pp 387-393 (Nov 1980) 6 figs, 11 refs

Key Words: Tanks (containers), Shells, Shells of revolution, Fluid-filled containers

The equations for thin shell-of-revolution tanks containing an arbitrary level of fluid are presented. The mass matrix can be used with any finite element or finite difference digital computer program that computes either the dynamic response or the natural frequencies and modes of a thin shell of revolution and that has provision for a nondiagonal mass matrix. The method does not require a numerical finite difference or finite element discretization of the fluid, but instead provides, in series form, a mass matrix that exactly satisfies the governing field equations for the fluid and satisfies the fluid-shell interface condition with a least-squares fit.

PIPES AND TUBES

(Also see Nos. 1896, 1907, 1983, 2042)

81-1952

Modal Content of Noise Generated by a Coaxial Jet in a Pipe

E.J. Kerschen and J.P. Johnston
Stanford Univ., Stanford, CA 94305, J. Sound Vib., 76 (1), pp 95-115 (May 8, 1981) 10 figs, 32 refs

Key Words: Pipes (tubes), Noise generation

Noise generated by air flow through a coaxial obstruction in a long, straight pipe of inside diameter, D = 97 mm, is investigated. Downstream modal pressure spectra in the 200-6000 Hz frequency range were measured by a new technique.

81-1953

Vibrations of Long Marine Pipes Due to Vortex Shedding

A.K. Whitney, J.S. Chung, and B.K. Yu
Lockheed Missiles & Space Co., Inc., Sunnyvale, CA, ASME Paper No. 81-Pet-29

Key Words: Pipes (tubes), Underwater pipelines, Vortex shedding, Root mean squares, Displacement analysis, Acceleration analysis

Lateral vibrational displacements and accelerations due to vortex shedding are analyzed for very long marine pipes with a bottom end mass for application to deep ocean-mining lift pipes. Estimates of maximum RMS values of displacement and acceleration are presented for a range of tow speeds, pipe lengths, pipe diameters and wall thicknesses, and for various values of the pipe end mass.

81-1954

Nonlinear Transient Motion of Deep Ocean Mining Pipe

J.S. Chung, A.K. Whitney, and W.A. Loden
Colorado School of Mines, Golden, CO 80401, J.

Engrg. Resources Tech., Trans. ASME, 103 (1), pp 2-10 (Mar 1981) 13 figs, 1 table, 26 refs

Key Words: Pipes (tubes), Underwater pipelines, Hydrodynamic excitation, Transient response, Beams, Time domain method

For accurate and economic time-domain analysis of deep ocean pipes, a realistic representation of hydrodynamic forces along the pipe and an efficient numerical method are required. A transient analysis procedure is formulated and implemented for the numerical determination of nonlinear transient motion of pipes using, as an initial condition, the nonlinear static configuration. The pipe is modeled by three-dimensional beam finite elements which account for coupled axial, bending and torsional deformations. Several cases are presented for accelerating, turning, and oscillatory motions of the ship and an 18,000-ft pipe, bottom end free. The subsurface environment and force coefficient selection greatly affects the results. The method can be directly applied to the analysis of deepsea risers and OTEC pipes.

DUCTS

81-1955

Sound Wave Propagation in Ducts Whose Walls are Lined with a Porous Layer Backed by Cellular Cavities

H. Yoshida
Dept. of Mech. Engrg., Chiba Univ., Yayoi-cho, Chiba 260, Japan, J. Sound Vib., 74 (4), pp 519-529 (Feb 22, 1981) 7 figs, 15 refs

Key Words: Ducts, Acoustic linings, Noise reduction, Acoustic absorption, Sound waves, Wave propagation

Propagation and attenuation of sound waves through acoustically lined ducts is studied. For a cylindrical duct whose liner consists of a point-reacting porous material layer backed by cellular cavities, the admittance formula derived by taking into account a wave motion within the liner is applied to an analysis of waves propagating downstream. For the point-reacting liner of fixed porous material properties, influences of the porous layer thickness, cellular cavity depth, mean flow profile, and three dimensionality of the duct (i.e., cylindrical or plane) on the attenuation are examined. The results show a significant role of the porous layer thickness. For the cylindrical duct, attenuation spectra evaluated from this analysis are compared with those given by the widely used semi-empirical formula.

81-1956

Stiffness Control of Low Frequency Acoustic Transmission through the Walls of Rectangular Ducts

A. Cummings
Inst. of Environmental Sci. and Tech., Polytechnic of the South Bank, London SE1 0AA, UK, J. Sound Vib., 74 (3), pp 351-380 (Feb 8, 1981) 15 figs, 12 refs

Key Words: Ducts, Walls, Sound transmission, Acoustic impedance, Fundamental frequency, Stiffness coefficients

The use of stiffness control to reduce low frequency acoustic breakout through the walls of rectangular air-moving ducts is investigated. Attempts are made to increase the fundamental transverse resonance frequency of the duct walls (by using materials with a high stiffness/mass ratio) so that the capacitive (stiffness) controlled nature of the wall impedance below this frequency may be exploited to raise the wall transmission loss and remove low frequency resonances. Some degree of success is achieved in this, and the results appear encouraging. The nature of the acoustic/structural wave combinations is explored in detail and a simplified low frequency approximate method of determining the transmission loss of ducts is given.

81-1957

Fan Noise Source Location from Field Measurements

A.M. Cargill
Noise Dept., Rolls-Royce Ltd., Derby, UK, Rept. No. PNR-90045, 14 pp (1980)
N81-17854

Key Words: Ducts, Fans, Noise source identification

Far-field duct mode fan noise detection and source location theory as well as experiments are studied. The effects of fan inlet ducting, far field sound and various ways of compensating for it are discussed. Problems of source location, such as the design of appropriate microphone arrays, are surveyed. Results from tests on a model aircraft engine fan are described which show that while source location techniques which utilize far field microphone arrays work well in principle, there are serious problems limiting their application to real fans. These include the difficulty in accounting for propagation along the duct, and the presence of highly coherent tones in the far field fan noise signature.

81-1958

The Transmission of Sound by Ventilation Ducts – A Design Guide

R.J.M. Craik and R.K. Mackenzie

Acoustic Res. Lab., Dept. of Bldg., Heriot-Watt Univ., Edinburgh EH1 1HX, UK, Appl. Acoust., 14 (1), pp 1-5 (Jan-Feb 1981) 1 fig, 4 tables, 2 refs

Key Words: Ducts, Ventilation, Sound transmission, Noise reduction, Design techniques

It has recently been shown that for situations in which two rooms are connected by a ventilation duct, the principal acoustic path from one room to the adjacent room is that via the duct cavity. As existing theories were found to be inadequate in predicting this path noise reduction, experiments have been carried out to determine the values of the unknown variables. These are described and a design guide for determining the overall noise reduction of the system has been produced.

81-1959

Acoustic Transmission in Non-Uniform Ducts with Mean Flow, Part 1: The Method of Weighted Residuals

W. Eversman and R.J. Astley

Dept. of Mech. and Aerospace Engrg., Univ. of Missouri, Rolla, MO 65401, J. Sound Vib., 74 (1), pp 89-101 (Jan 8, 1981) 2 figs, 2 tables, 21 refs

Key Words: Ducts, Sound transmission, Method of weighted residuals

In this and a companion paper the problem of transmission of sound through non-uniform ducts carrying a high speed subsonic compressible flow is approached using the method of weighted residuals (MWR) in the form of a modified Galerkin method and the finite element method (FEM). The intent of the investigation is to carry out a careful evaluation of these methods in this computationally difficult problem. To this end both MWR and FEM have been limited to in-core computer implementations to generate useful results with relatively modest computational requirements. This paper (Part I) details the MWR formulation and presents numerical results establishing the degree of accuracy of MWR as compared to exact eigenvalue calculations and approximate one dimensional transmission calculations. The comparison of MWR and FEM results is carried out in the companion paper (Part II).

81-1960

Acoustic Transmission in Non-Uniform Ducts with Mean Flow, Part II: The Finite Element Method

R.J. Astley and W. Eversman

Dept. of Mech. Engrg., Univ. of Canterbury, Christchurch, New Zealand, J. Sound Vib., 74 (1), pp 103-121 (Jan 8, 1981) 9 figs, 3 tables, 18 refs

Key Words: Ducts, Sound transmission, Finite element technique

This second paper in a two part series describes the implementation of the finite element method for the solution of the problem of acoustic transmission through a non-uniform duct carrying a high speed subsonic compressible flow. A finite element scheme based on both the Galerkin method and the residual least squares method and with eight noded isoparametric elements is described. Multimodal propagation is investigated by coupling of the solution in the duct non-uniform section to modal expansions in uniform sections. The accuracy of the finite element results for both the eigenvalue and transmission problems is assessed by comparison with exact solutions and with results from the method of weighted residuals in the form of a modified Galerkin method as introduced in Part I of this pair of papers. The results of calculations show that modal interactions, particularly in transmitted modes, become increasingly important with increasing duct flow Mach number. Power transmission coefficient calculations for the geometries studied reveal no indication of a linear basis for the phenomenon of subsonic acoustic choking.

81-1961

On the Propagation of Long Waves in Acoustically Treated, Curved Ducts

W. Rostafinski

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-81712; E-745, 21 pp (1981)

N81-19875

Key Words: Ducts, Curved ducts, Acoustic linings, Elastic waves

A two dimensional study is presented on the behavior of long waves in lined, curved ducts. The analysis includes a comparison between the propagation in curved and straight lined ducts. A parametric study is conducted over a range of wall admittance and duct wall separation. The complex eigenvalues of the characteristic equation, which in the case of a curved duct are also the angular wavenumbers, are obtained by successive approximations.

BUILDING COMPONENTS

81-1962

Concrete Coupled Walls: Earthquake Tests

J.M. Lybas

Dept. of Civil Engrg., Univ. of Florida, Gainesville, FL 32611, ASCE J. Struc. Div., 107 (5), pp 835-856 (May 1981) 16 figs, 6 tables, 7 refs

Key Words: Walls, Concretes, Reinforced concrete, Seismic excitation, Earthquake response

Tests of six approximately one-twelfth scale reinforced concrete coupled walls under seismic loading are described; the results are compared to collapse mechanisms calculated by conventional means. Five structures were subjected, on an earthquake simulator, to the base acceleration record measured at El Centro, California, during the Imperial Valley earthquake of 1940; one was subjected to slow cyclic loading and the inelastic range. The major variables in the study were the strength and stiffness of the connecting beams. In evaluating the experimental results, the effect of microcracking on the initial stiffness of the structure is noted, as are the effects of higher mode response in the accelerations, base shear and base moment. Using lateral loading in the shape of the first mode, the collapse mechanisms for the test structures, varying with strength and stiffness of the connecting beams, are determined.

81-1963

Response of RC Shear Wall under Ground Motions

A.B. Agrawal, L.G. Jaeger, and A.A. Mufti

Civil Engrg. Dept., M.N.R. Engrg. College, Allahabad-211004, U.P., India, ASCE J. Struc. Div., 107 (2), pp 395-411 (Feb 1981) 9 figs, 2 tables, 29 refs

Key Words: Walls, Ground motion, Reinforced concrete, Concretes, Earthquake response, Finite element technique

The formulation is presented of an analytical model using the finite element technique to compute the nonlinear dynamic behavior of reinforced concrete planar structures under earthquakes. The model is based on a lumped-mass approach, and utilizes the Newmark β-method to perform the step-by-step integration of the equations of motion. This model is applied to trace the response of a three story shear-wall subject to the El Centro earthquake of May 1940. The results computed are compared with an experimental *investigation.*

18-1964

Torsional Vibration of Along-Wind Excited Structures

D.A. Foutch and E. Safak

Univ. of Illinois at Urbana-Champaign, Urbana, IL 61801, ASCE J. Engrg. Mechanics Div., 107 (2), pp 323-337 (Apr 1981) 8 figs, 14 refs

Key Words: Wind-induced excitation, Structural members, Torsional vibration, Random excitation

A method for analyzing the torsional vibration of along-wind excited structures is presented. The method is based on random vibration concepts and yields the expected maximum translational and torsional responses of a single-mass structure. The approach is similar to the gust factor method. Aerodynamic admittance functions are derived which are used to estimate the spectral density function of the random torque and the cross-spectral density function of the force and torque acting on the structure. These are required for estimating the structure's translational and torsional mean square responses. Results for several examples indicate that the dynamic torsional response increases as follows: as the width of the structure's exposed face increases, as the structural or geometric eccentricity increases, and as torsional natural frequency decreases.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 1865, 1876, 1877, 1882, 1883, 1919, 2005, 2028, 2045, 2046)

81-1965

Asymptotic Analysis of the Torsional Modes of Wave Propagation in a Piezoelectric Solid Circular Cylinder of (622) Class

H.S. Paul and D.P. Raju

Dept. of Mathematics, Indian Inst. of Tech., Madras-600 036, India, Intl. J. Engrg. Sci., 19 (8), pp 1069-1076 (1981) 2 tables, 11 refs

Key Words: Piezoelectricity, Asymptotic approximation, Torsional response, Wave propagation

An asymptotic method due to Achenbach is used to analyze the torsional modes of wave propagation in a solid circular cylinder of piezoelectric material of (622) crystal class. Information obtained in this method is useful for the frequency spectrum at long wavelengths. In this method, the field variables and the frequency are expressed as power series of the dimensionless wavenumber, $\epsilon = 2\pi \times R/W$. Substituting these expansions in the field equations and the boundary conditions, a system of coupled second order inhomogeneous ordinary differential equations with the radial coordinate

as independent variable obtained by collecting the terms of same order ϵ^m. Integration of such systems of differential equations yield the various terms in the series expansions for the above modes and for the whole range of frequencies, when the real-valued dimensionless wavenumber less than unity $(0 < \epsilon < 1)$. To test the correctness of the present scheme, the roots of the exact frequency equation are computed in double precision and the results thus obtained are compared with the results obtained in the present analysis.

81-1966

On the Interaction of a Sound Pulse with the Shear Layer of an Axisymmetric Jet

L. Maestrello, A. Bayliss, and E. Turkel
NASA Langley Res. Ctr., Hampton, VA 23665, J. Sound Vib., 74 (2), pp 281-301 (Jan 22, 1981) 10 figs, 38 refs

Key Words: Acoustic pulses, Jet noise, Amplification, Acoustic absorption

The behavior of a sound pulse from a simulated source in a jet is investigated both experimentally and numerically. Both approaches show that in the low and medium frequencies the far field acoustic power exhibits a marked amplification as the flow velocity increases. Experimentally this changes to an attenuation at the higher frequencies which cannot be computed by the numerical model. This amplification is traced to shear noise terms which trigger the instability waves that are inherent within the flow.

81-1967

Scattering of Surface Waves by a Sub-Surface Crack

J.D. Achenbach and R.J. Brind
Technological Inst., Northwestern Univ., Evanston, IL 60201, J. Sound Vib., 76 (1), pp 43-56 (May 8, 1981) 6 figs, 7 refs

Key Words: Cracked media, Elastic waves, Wave diffraction

The scattering of Rayleigh waves by a two-dimensional subsurface crack, which is perpendicular to the free surface of an elastic half-space, is investigated. The boundary-value problem for the scattered field is stated, and reduced to an uncoupled system of integral equations which are solved numerically. At large distances from the crack the scattered field is shown to consist of outgoing Rayleigh waves and cylindrical body waves. Graphs of the variation of the amplitude and phase of the forward and backward scattered Rayleigh waves with the frequency and the geometrical parameters of the crack are presented. The stress intensity factors at both crack tips have also been obtained.

81-1968

On the Unsteady Wake-Induced Lift on a Slotted Airfoil, Part II: The Influence of Displacement Thickness Fluctuations

M.S. Howe
Bolt, Beranek & Newman, Inc., 40 Moulton St., Cambridge, MA 02138, J. Sound Vib., 74 (3), pp 311-320 (Feb 8, 1981) 4 figs, 9 refs

Key Words: Airfoils, Discontinuity-containing media, Sound waves

In the preceding companion paper a theoretical model for determining the influence of a slot in a thin airfoil on the unsteady lift/radiated sound caused by vortices shed into the wake was presented. The unsteady motion produces additional vorticity at the upstream edge of the slot, and it was shown that, at sufficiently low reduced frequencies based on the width of the slot, this vorticity can prevent penetration by the flow, so that the airfoil behaves as if the slot were absent. At higher frequencies, however, both the lift and the sound power were predicted to be significantly reduced relative to their respective levels for the unslotted airfoil. The analysis is extended in this paper to include the effects of displacement thickness fluctuations of the boundary layers on the "flap" downstream of the slot. These fluctuations arise as a result of the periodic ejection of vorticity from the slot. It is concluded that the earlier predictions of a reduction in the lift/sound pressure level are enhanced by the displacement thickness effects.

81-1969

Mixing of Normal Modes in a Range-Dependent Model Ocean

I. Thompson
Dept. of Physics, The Univ. of Auckland, Auckland, New Zealand, J. Acoust. Soc. Amer., 69 (5), pp 1280-1289 (May 1981) 13 figs, 15 refs

Key Words: Underwater sound, Sound waves, Wave propagation

The problem of calculating the horizontal propagation of sound along a range-dependent underwater channel is solved in a model using a harmonic-oscillator expansion for the vertical pressure distribution. This oscillator basis set is constant for all ranges. The local normal modes at any range

may be recovered by a matrix diagonalization, but this is only strictly necessary at the range limits, to define the outgoing boundary conditions. The method is capable of handling arbitrary range dependencies, and is applied to a range of constant gradients to reveal three propagation regimes.

81-1970

A Study of the Sonic-Boom Characteristics of a Blunt Body at a Mach Number of 6

G.C. Ashby, Jr.

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TP-1787; L-14017, 34 pp (Dec 1980) N81-13915

Key Words: *Sonic boom, Acoustic signatures*

An experimental and analytical study of the sonic boom static pressure signatures generated by a blunt body at Mach 6 has shown that finite difference computer programs can be used to give reasonable estimates of the signatures. The calculated near field static pressure signature was extrapolated to the far field by a program using the method of characteristics. A comparison of this extrapolated signature with the signature predicted by far field sonic boom theory (linearized) shows that peak overpressures are about the same, at least up to Mach, but the far field theory overestimates the length of the signature.

81-1971

Method of Measuring Transmission Paths

F.X. Magrans

Laboratorio de Acustica, Centro Tecnico S.E.A.T., Barcelona, Spain, J. Sound Vib., 74 (3), pp 321-330 (Feb 8, 1981) 8 figs, 7 refs

Key Words: Sound transmission, Measurement techniques

A theoretical explanation and experimental proof are presented of a method for localizing and evaluating the transmission paths of any signal in a "black box" among a set of points previously defined in it. The signal should behave linearly and the system should be able to receive external excitations seperately at each of its points. Such excitations need not be the signal under study but they should be linearly related to it. Also presented are the equations that, once the transmission paths have been determined, allow the evaluation of the excitations which act on the system.

81-1972

Statistical Analyses of Urban Noise

S. Fidell, R. Horonjeff, and D.M. Green

Bolt, Beranek & Newman, Inc., P.O. Box 633, Canoga Park, CA 91305, Noise Control Engrg., 16 (2), pp 75-80 (Mar-Apr 1981) 8 figs, 4 refs

Key Words: Noise reduction, Urban noise, Statistical analysis

Spectral and temporal regularities underlie the seeming unpredictability of the urban noise environment. Two distinct processes that contribute to urban noise were inferred from analyses of recordings made in areas of high, moderate and low population density. The relative contributions of the two processes to the ambient noise environment were estimated at different times of day. The interaction between strength of association (linear correlation) of levels in adjacent frequency regions and population density is examined. Interpretations of these relationships can provide guidance for several types of community noise control projects.

81-1973

Noise Reduction by Various Shapes of Barrier

M. Yuzawa and T. Sone

Tohoku Inst. of Tech., Sendai 982, Japan, Appl. Acoust., 14 (1), pp 65-73 (Jan-Feb 1981) 7 figs, 1 table, 3 refs

Key Words: Noise barriers, Noise reduction, Geometric effects

Noise reduction by various shapes of finite barrier can be achieved by applying the Fresnel-Kirchhoff diffraction theory and primarily follows the ideas of Maekawa. The calculated results for several kinds of small-scale models are compared with experimental results.

81-1974

Road Traffic Noise Attenuation by Belts of Trees

J. Kragh

Acoustical Lab., The Danish Academy of Technical Sci., DK-2800 Lyngby, Denmark, J. Sound Vib., 74 (2), pp 235-241 (Jan 22, 1981) 2 figs, 1 table, 2 refs

Key Words: Traffic noise, Noise reduction, Trees (plants)

Measurements were made at a number of sites of road traffic noise propagating through belts of trees and bushes and

above grass-covered ground, respectively. The belt widths were between 3 and 25 m. The distance from the road to the front of the belts also varied from site to site. The microphones were placed 1.5 m above the ground. The belts of the trees selected consisted mainly of deciduous trees and bushes between 5 and 10 years of age. Such types and widths are representative of what could often be used in normal urban situations in an attempt to provide practical noise reduction.

81-1975

A Demonstration of Active Control of Broadband Sound

C.F. Ross

Dept. of Engrg., Univ. of Cambridge, Cambridge CB2 1PZ, UK, J. Sound Vib., 74 (3), pp 411-417 (Feb 8, 1981) 7 figs, 2 refs

Key Words: Noise reduction, Active control, Industrial facilities

A short experiment undertaken to demonstrate how easily broadband active control of sound can be used to tackle real industrial problems is described. Ten decibels of the low frequency sound entering an anechoic chamber through a lobby was blocked by using a single degree of freedom system.

81-1976

Revised Noise Criteria for Application in the Acoustical Design and Rating of HVAC Systems

W.E. Blazier, Jr.

Warren Blazier Assoc., 50 California St., Suite 2335, San Francisco, CA 94111, Noise Control Engrg., 16 (2), pp 64-73 (Mar-Apr 1981) 7 figs, 11 refs

Key Words: Noise measurement, Air conditioning equipment

Current methods of rating the noise produced by heating, ventilating and air conditioning systems are reviewed. It is explained why these ratings fail to be correlated with subjective opinion in many cases. An entirely new method of assigning noise ratings is proposed which is expected to provide a significantly better correlation between objective measurements and subjective response.

81-1977

Acoustic Impedance of an Isotropic Medium for Rayleigh Waves

A. Opilski and M. Urbańczyk

Inst. of Physics, Silesian Polytechnic, 44-100 Gliwice, Poland, Arch. Acoust., 5 (3), pp 191-196 (1980) 3 refs

Key Words: Acoustic impedance, Rayleigh waves

The acoustic impedance of an isotropic non-piezoelectric medium has been determined for Rayleigh waves. The numerical values of this impedance are very different from the values of the impedance of the medium for a plane bulk wave.

SHOCK EXCITATION

(Also see Nos. 1930, 2008)

81-1978

Weak Shock Waves in Non-Heat Conducting Thermoelastic Materials -- Variation of Amplitude of the Weak Shocks

E. Ukeje

Dept. of Mathematics, Univ. of Nigeria, Nsukka, Nigeria, Intl. J. Engrg. Sci., 19 (9), pp 1187-1201 (1981) 9 refs

Key Words: Shock wave propagation, Thermoelasticity

An attempt is made to study the propagation of weak shock waves in a thermoelastic material that does not conduct heat. The velocity of propagation of such shocks is examined. Equations governing the growth and decay of plane shocks and shocks of arbitrary form are derived and studied.

81-1979

Finite Element Modelling of Ground Surface Displacements Due to Underground Blasting

D.P. Blair

C.S.I.R.O., Div. of Appl. Geomechanics, Syndal, Victoria, Australia, Intl. J. Numer. Anal. Methods Geomech., 5 (2), pp 97-113 (Apr-June 1981) 11 figs, 22 refs

Key Words: Shock waves, Shock wave propagation, Underground explosions, Explosions, Finite element technique

Elastic wave radiation from an equivalent cylindrical cavity due to an underground explosion is considered in detail. Both static and steady state dynamic finite element models

are used to investigate the surface displacements due to the interaction of such wave radiation with both the free surface topography and stope formation. For a blast 430 m below the surface the models predict a negligible displacement effect due to the irregular topography but a significant effect due to the stope. A comparison between the models and a site experiment verified the cylindrical wave nature of the problem.

81-1980

Shock Waves, How to Recognize Them, Use Them, and to Provide Against Them (Les Ondes de Choc, Les Connaitre, Les Utiliser, S'en Premunir)

C. Mas

Societe Nationale Industrielle Aerospatiale, Les Mureaux, France, Rept. No. SNIAS-792-422-102, 11 pp (1979) (Congr. on Explosifs et Pyrotech. Appl. Spatiales, Toulouse, Oct 22-25, 1979)

N81-16985

(In French)

Key Words: Shock waves, Shock wave propagation, Missile launching, Shock response spectra, Computer programs

The use of one and two dimensional computer programs for detonation studies (wave propagation) is described. Experimental work encountered in the literature is presented together with the results of accelerometry measurements made to define shock spectra envelopes recorded on missile and missile launching structures. The way in which pyrotechnic shock effects on materials are predetermined is discussed. Mathematical modeling techniques and the appropriate calculations which enable the pyrotechnic forces to be understood and exploited are examined.

81-1981

Experiments on the Stability of Converging Cylindrical Shock Waves

J.H.T. Wu, R.A. Neemeh, and P.P. Ostrowski

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Rept. No. LOG-J11846, 26 pp (Aug 1, 1980)

N81-16419

Key Words: Shock waves, Shock wave propagation

A shock tube which employs a series of conical contractions to direct a plane, annular incident shock wave into a cylindrical implosion chamber was used for an incident shock Mach number as low as 1.79. Highly symmetrical implosions at early times were achieved although an eventual breakdown in shock front curvature was always noted at *small radius* regardless of the initial Mach number. The cylindrical shock Mach number variation and trajectory was found to be well predicted by the Chester-Chisnell-Whitham (CCS) area Mach number relation. Spark shadowgraph photography was used *to demonstrate* the inherent instability of converging cylindrical shocks by introducing obstacles in the path of the shock, upstream and downstream of the conical contractions. Whitham's ray shock theory was applied to provide an insight into the mechanism of instability associated with perturbed converging shocks. It is shown that a breakdown in shock front curvature is a natural and necessary consequence of initial asymmetries and that this instability phenomenon is signaled by the appearance of clockwise and counterclockwise rotating vortex pairs during the later diverging shock motion.

81-1982

Doubly Asymptotic, Boundary-Element Analysis of Dynamic Soil-Structure Interaction

P. Underwood and T.L. Geers

Lockheed Palo Alto Research Lab., 3251 Hanover St., Palo Alto, CA 94304, Intl. J. Solids Struc., 17 (7), pp 687-697 (1981) 6 figs, 23 refs

Key Words: Interaction: soil-structures, Boundary element technique, Doubly asymptotic approximation method, Ground shock

A doubly asymptotic (DA), boundary-element (BE) treatment of dynamic soil-structure interaction where the surrounding medium is treated as linear-elastic is described. The interaction is reduced to a surface relationship that is *asymptotically exact at both high and low frequencies.* Governing equations are developed in matrix form for application to complex structures. Numerical results are presented for a two-dimensional problem for which analytical solutions have appeared in the literature. Good agreement between the DA/BE and analytical results is observed.

81-1983

Dispersion Relations of Waves in a Rod Embedded in an Elastic Medium

R. Parnes

Dept. of Solid Mech., Materials and Structures, Tel Aviv Univ., Ramat Aviv, Israel, J. Sound Vib., 76 (1), pp 65-75 (May 8, 1981) 6 figs, 7 refs

Key Words: Wave propagation, Elastic media, Pipelines, Seismic excitation

The dispersion relations of waves propagating in a system consisting of an elastic rod of radius a embedded in a linear elastic medium are investigated, and phase speeds of waves of wavelength λ which propagate under steady state conditions are determined. The dispersive behavior is found to be dependent on several non-dimensional parameters defined by the geometric ratio a/λ, as well as on non-dimensional ratios of the rod-medium properties. It is shown that the resulting waves which can propagate under steady state conditions are surface waves which decay with the radial distance and which permit no radiation damping of energy. It is further shown that such waves can propagate freely only if the propagation speed of longitudinal waves in the corresponding free rod is less than that of shear waves propagating in the medium. Results are presented by means of dispersion curves and surfaces. From a study of the analytical results obtained, lower and upper bounds on the phase speeds are established.

VIBRATION EXCITATION

(Also see Nos. 1821, 1930)

81-1984

On the Effects of Variable Magnitude Traveling Loads

J. Padovan
The Univ. of Akron, Akron, OH 44325, Intl. J. Engrg. Sci., 19 (9), pp 1203-1219 (1981) 12 figs, 9 refs

Key Words: Variable amplitude excitation, Moving loads, Structural response, Plates, Viscoelastic properties

The effects of traveling load variability on visco-elastic type structural response behavior are determined. Emphasis is given to determining the existence of critical speed shifts as well as the occurrence of potential speed bifurcations. Structural behavior in the various sub, trans and supercritical load speed ranges is investigated with particular consideration given to situations involving bifurcations. Since plates exhibit many of the essential features of most structure, emphasis is given to traveling external loads on plate strips. To characterize the various aspects of the variable load induced critical speed shifts and bifurcations, the results of several numerical examples are presented. These illustrate typical behavior in the sub, trans and supercritical ranges of traveling speed.

81-1985

Response of Nonlinear Mechanical Systems to Random Excitation. Part 2: Equivalent Linearization and Other Methods

J.B. Roberts
School of Engrg. and Applied Sci., Univ. of Sussex, Falmer, Brighton, Sussex BN1 9QT, UK, Shock Vib. Dig., 13 (5), pp 15-29 (May 1981) 121 refs

Key Words: Reviews, Random excitation, Equivalent linearization method

Part I of this survey discussed Markov methods for solving nonlinear stochastic problems in dynamics. This second part considers a number of alternative approximate methods, including equivalent linearization, perturbation, functional series representation, and simulation.

81-1986

Non-Linear Analysis of Stick/Slip Motion

T.K. Pratt and R. Williams
Pratt & Whitney Aircraft Group, Commercial Products Div., United Technologies Corp., East Hartford, CT 06108, J. Sound Vib., 74 (4), pp 531-542 (Feb 22, 1981) 9 figs, 1 table, 5 refs

Key Words: Stick-slip response, Coulomb friction, Harmonic excitation, Nonlinear theories

The steady state relative motion of two masses with dry (Coulomb) friction contact is investigated. The bodies are assumed to have the same mass and stiffness and are subjected to harmonic excitation. By means of a combined analytical-numerical procedure, results are obtained for arbitrary values of Coulomb friction, excitation frequency, and natural frequencies of the bodies. For certain values of these parameters, multiple lockups per cycle are possible. In this respect, the problem investigated here is a natural extension of the one considered by Den Hartog, who in obtaining his closed form solution assumed a maximum of two lockups per cycle.

81-1987

Adaptive Notch Filter Suppression of Bending Modes

W.L. Marks
Master's Thesis, Naval Postgraduate School, Monterey, CA, 223 pp (Dec 1980)
AD-A094 554

Key Words: Flexural vibration, Vibration control

A simple, microprocessor oriented algorithm is developed to identify, track and suppress bending mode signals from a

control system's rate and position feedback signals using adaptive digital notch filters. The algorithm can be used to suppress bending modes having center frequencies as close as one octave above the control system gain cross-over frequency without introduction of the excessive phase loss associated with conventional lowpass filtering techniques. A third order model of the trident missile autopilot pitch attitude control loop is contaminated with two dynamic, destabilizing bending modes and used as a concept demonstration model. The algorithm is demonstrated by stabilizing the pitch attitude loop in the presence of two bending modes with unknown gains, damping, center frequencies and rates of change of center frequencies.

81-1988

Spatial Concentrations of Random Response in Point-Excited Waveguides

P.W. Smith, Jr.
Bolt, Beranek & Newman Inc., Cambridge, MA 02138, J. Acoust. Soc. Amer., 69 (5), pp 1337-1342 (May 1981) 5 figs, 7 refs

Key Words: Waveguide analysis, Point source excitation, Random response

A recent modal analysis shows that a marked spatial concentration of the mean-square response (larger than the spatial average by a factor 4) may exist in a dynamical system excited by a wideband, localized random force. Response is largest near the source. The system has distributed damping and a cutoff frequency below which waves could not freely propagate in an infinite, undamped system; the finite system has large modal density and strong modal overlap near the cutoff frequency. The same system is examined here by a multiple-scattering analysis. It is shown that the spatial concentration, ascribed in the modal analysis to cross correlation between the responses of many modes, is largely described by the direct field (the first term of the scattering series) and is associated with a narrow band of response near the cutoff frequency, where free waves are strongly attenuated. Closed-form analytical approximations are developed in terms of the fundamental dynamical parameters.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 1805, 1875, 1885)

81-1989

Dynamic Damping System

C.F. Grove
Dept. of the Air Force, Washington, D.C., PAT-APPL-6-192 406, 17 pp (Sept 1980)

Key Words: Dampers, Dynamic vibration absorption (equipment), Active damping

A dynamic damping system for stabilizing the motion of a large object with respect to inertial space by adding mechanical damping to an angular positioning servo system for the object is described. The mechanical damping is achieved by a dynamic damper assembly which attaches to an inertial balancer that provides inertia feedback to the servo system. The dynamic damper assembly along with the inertia balancer mechanically assist the positioning servo system.

81-1990

Damping of Frames with Viscoelastic Infill Panels

D.A. Gasparini, L.W. Curry, and A. DebChaudhury
Dept. of Civil Engrg., Case Western Reserve Univ., Cleveland, OH 44106, ASCE J. Struc. Div., 107 (5), pp 889-905 (May 1981) 11 figs, 8 tables, 18 refs

Key Words: Panels, Viscoelastic damping, Energy absorption, Frames, Multistory buildings

The effectiveness of energy absorbing infill panels as a passive means for increasing damping and minimizing vibration is examined. Methods for designing such infills, simplified models for dynamic analysis and analyses for predicting effective damping are considered. Viscoelastic constitutive equations are used to model the linear damping capacity of steel and the highly damped material. The effective damping of infilled frames is determined by computing steady state responses to harmonic lateral excitation. A particular infill panel configuration is suggested, and a simplified dynamic model, consisting of an equivalent plain stress rectangle, is verified and used for the dynamic analyses. Steady state responses are computed for a sixteen story, steel rigid frame with and without infill panels. Significant increases in the damping of the steel frame can be realized.

FATIGUE

(Also see Nos. 1834, 1870, 1938)

81-1991

Examination of Fatigue Behavior in Composite Structures under Load (Schwingfestigkeitsuntersuchungen an Fuegungen in Faserbauweise)

J.J. Gerharz, D. Rott, and D. Schuetz

Bonn Bundesministerium fuer Verteididung, Rept. No. BMVg-FBWT-79-23, 91 pp (1979)
N81-17496
(In German, English summary)

Key Words: Fatigue life, Composite structures, Bolts, Joints (junctions), Plates, Aircraft

To provide design data for graphite/epoxy composite structures, stress-strain behavior during monotonic loading, fatigue behavior, and deformation behavior during cyclic loading of composite bolted joints were investigated to provide design data for graphite/epoxy composite structures. The laminate structure of the jointed composite plates was tuned to load conditions in aircraft fuselage skins. Results show that the stress strain behavior of the composite joints is extensively nonlinear under increasing tensile or compressive loads. The fatigue behavior of the composite joints, during constant amplitude loading with the stress ratio at 1.66, shows the deepest drop in fatigue strength as to static strength. In the low cycle region, the negative influence of the stress concentration is largest, decreasing more and more with decreasing stress levels until it has vanished in the fatigue limit region.

81-1992

Prevention of Vibration Caused Damage in Water Turbine Wheels (Vermeidung von Schwingungsschaden an Laufrädern von Wasserturbinen)

W. Tauffkirchen, G. Benedikter, and T. Varga
Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 53-60 (1980) 15 figs, 3 refs
(In German)

Key Words: Fatigue life, Experimental test data, Design techniques, Turbine components, Wheels

Water-turbine wheel failures are often caused by fatigue cracks. Relief can be provided by design changes, for which the knowledge of operational stresses is needed. Two methods for measuring operational stresses on Pelton water wheels are described. In the first case a fatigue crack is measured; the second case deals with testing of a new design.

81-1993

Wind Machine Fatigue Analysis and Life Prediction

C.A. Waldon
Rockwell International Corp., Golden, CO, Rept. No. RFP-3135/3533/80-19, 66 pp (Apr 1980)
N81-19495

Key Words: Fatigue life, Wind-induced excitation, Measurement techniques, Prediction techniques

A technique for measuring fatigue and predicting fatigue life for different wind regimes is described. Presented are the techniques for locating high stress measuring points, obtaining data, using computer programs for calculating fatigue reduction, and finally predicting fatigue life.

81-1994

Prediction of Fatigue-Crack Growth under Variable Amplitude and Spectrum Loading Using a Closure Model

J.C. Newman, Jr.
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-81942, 38 pp (Jan 1981) (ASTM Symp. Design of Fatigue and Fracture Resistant Struct., Bal Harbour, FL, Nov 10-14, 1980)
N81-19486

Key Words: Fatigue life, Crack propagation

An existing analytical crack closure model was used to study crack growth under various load histories. The model was based on a concept like the Dugdale model, but modified to leave plastically deformed material in the wake of the advancing crack tip. The model was used to correlate crack growth rates under constant amplitude loading, and to predict crack growth under variable amplitude and aircraft spectrum loading on 2219-T851 aluminum alloy sheet material. The predicted crack growth lives agreed well with experimental data.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

81-1995

Definitions and Frequency Domain Procedures for Dynamic Data Analysis

J.S. Bendat

J.S. Bendat Company, Los Angeles, CA, Intl. J. Vehicle Des., 2 (2), pp 227-245 (May 1981) 2 refs

Key Words: Frequency domain method, Reviews

This paper contains definitions, notation and computational procedures recommended for analyzing dynamic data properties of stationary or transient random data, including their passage through physical systems.

81-1996

Installation of Permanent Displacement Pick Ups for Turbomachinery Monitoring (Einsatz von permanent installierten Wegaufnehmern zur Schadensverhütung an Turbomaschinen)

W. Scheithe and W. Trommer

Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 77-80 (1980) 6 figs (In German)

Key Words: Measuring instruments, Displacement transducers, Turbomachinery

The performance and reliability of non-contacting displacement pick ups used for the measurement of turbomachinery vibrations are evaluated. The discussion is limited to pick ups operating on the eddy current measuring principle. Criteria in the evaluation are based on the size, the resistance to environmental effects such as temperature, as well as the measuring properties of the pick up.

81-1997

Vibration Pick-Ups with Electret (Material) (Schwingungsaufnehmer mit Elektret)

M. Vömel

Institut f. Elektromechanische Konstruktionen der Technischen Hochschule, Darmstadt, Germany, Feinwerk u. Messtechnik, 89 (2), pp 85-86 (Mar 1981) 6 figs, 4 refs
(In German)

Key Words: Vibration measurement, Measuring instruments

A new type of mechanical electrical vibration pick-up with electret material has an almost frequency-independent transfer factor and phase angle in a frequency range of 30 to 100 Hz. The large transfer factor of 7mV/μm enables its use in precision measuring devices for vibration measuring. The detailed description of the construction and a simplified calculation of the system, shows the advantages and limits of the use of electret material in such a pick-up.

81-1998

Generation of Acousto-Electrical Waves Using a Source of Transverse Vibrations

N.V. Kinh and W. Pajewski

IPPT PAN, 00-149 Warszawa, ul. Świetokrzyska 21, Poland, Arch. Acoust., 5 (3), pp 261-274 (1980) 7 figs, 10 refs

Key Words: Piezoelectric transducers, Measuring instruments

A theoretical analysis of the generation of transverse surface waves, using a linear source of vibrations, placed in the plane in which the generated wave propagates, is presented. On the basis of the results of the theory presented, the problem of the generation of a surface wave excited by a source of finite dimensions in the form of piezoelectric plates is considered. This method of wave generation was used for the generation of transverse surface waves on a piezoelectric ceramic and on niobiate and iodate of lithium.

81-1999

Measurements of Wind and Deformation on a High Radio Tower. Part 2. Instruments to Measure the Tower-Deformation and the Free-Streaming Wind (Wind- und Verformungsmessungen an einem Funkturm. Teil 2. Geräte zur Messung der Turmverformung und des ungestörten Windes)

W. Neuerburg

Maschinenlaboratorium 2 der Fachhochschule f Technik Esslingen, Kanalstr. 33, D-7300 Esslingen, Germany, Techn. Messen-ATM, 48 (4), pp 139-145 (Apr 1981) 10 figs, 15 refs
(In German)

Key Words: Measuring instruments, Towers, Wind-induced excitation

Wind loadings on a high tower structure and the coherent effects of static and dynamic responses were studied by means of versatile measurement equipment. Wind pressures against the tower wall, the deformation and oscillation of the structure and the free-streaming wind were measured. Part 2 of this article describes instrumentation for measuring deflection of the structure and wind velocity.

81-2000

Low-Cost Computer Controlled Acoustic Measuring Systems

N.W. Heap and D.J. Oldham
Faculty of Tech., Open Univ., Milton Keynes MK7 6AU, UK, Appl. Acoust., 14 (1), pp 43-48 (Jan-Feb 1981) 4 figs

Key Words: Acoustic measuring instruments, Measuring instruments, Computer-aided techniques

A low-cost micro-computer can be simply interfaced to conventional analogue equipment so as to provide a semi-automated acoustic measurement system. Input and output interfaces are described, together with the control signals and program instructions required to operate the system.

81-2001

Optical Path-Measuring Probe (Optische Wegmesssonde)

H. Buschmann
Institut f. Elektromechanische Konstruktionen der Technischen, Hochschule, Darmstadt, Germany, Feinwerk u. Messtechnik, 89 (2), pp 87-89 (Mar 1981) 6 figs, 2 refs
(In German)

Key Words: Measuring instruments, Optical probes, Optical measuring instruments

An optical path-measuring probe is described whose measuring gap is 20 mm long, 10 mm wide and 2 mm high. The object to be measured, or a moving lug attached to the measuring object, moves in this measuring gap. In the gap the device uses several light sources and scattered light, so that the linearity can be maintained under 1% error even after ageing. The effect of outside light remains under 1.5% of the measuring range (15 mm) even in unfavorable cases. This device is small, handy and economical, and can measure deflections of about 0.1 - 30 mm at frequencies of up to several kHz.

81-2002

Recursive Digital Filters for Real-Time Applications. Part 1: Low-Pass Filters (Rekursive Digitalfilter f. Echtzeitanwendungen. Teil 1: Tiefpassfilter)

E. Schwieger
Institut f. Physik, GKSS Forschungszentrum Geesthacht GmbH, Reaktorstrasse 1, 2054 Geesthacht, Techn. Messen-ATM, 48 (4), pp 119-125 (Apr 1981) 18 figs, 7 refs
(In German)

Key Words: Filters, Digital filters, Real time spectrum analyzers

An algorithm for the design of recursive digital filters using the bilinear z-transformation is presented. These filters are attractive especially for real-time applications because they require few computations per data point. Amplitude and phase are calculated to show the filter characteristics in a manner similar to continuous filter design. A first and second order low-pass filter and two filter combinations are realized as subroutines in the FORTRAN language. The quality of the chosen filters is demonstrated by test calculations.

81-2003

An Experimental Comparison of Optimum and Sub-Optimum Filters' Effectiveness in the Generalized Correlator

J.C. Hassab and R.E. Boucher
Naval Underwater Systems Ctr., Newport, RI 02840, J. Sound Vib., 76 (1), pp 117-128 (May 8, 1981) 3 figs, 3 tables, 15 refs

Key Words: Filters, Cross correlation technique

Various optimum and sub-optimum filters have been added to the basic cross-correlator in order to enhance its detection and estimation capabilities in the presence of noise. These pre-detection filters include the Hannan-Thomson, the Eckart, the Smoothed Coherence Transform, some least-squares, and two optimum filters recently derived by he authors. Here, a quantitative comparison of all six filters has been conducted by extensive simulation for various input signal to noise ratios and signal and noise bandwidths. The results define the actual enhancement in time delay detection and estimation when using the optimum filters and the amount of performance degradation from the optimum for the other filters. The rank ordering of the filters is carried out. Histograms of the time delay estimates, their mean, variance and probability of detection are presented. Comparison of analytical predictions with the experimental results is noted.

81-2004

The Effect of Bandwidth on the Accuracy of Transfer Function Measurements of Single Degree of Freedom System Response to Random Excitation

A.W. Walker

Admiralty Marine Tech. Est., Teddington TW11 0LN, UK, J. Sound Vib., 74 (2), pp 251-263 (Jan 22, 1981) 7 figs, 4 refs

Key Words: Measurement techniques, Frequency response function, Single degree of freedom systems, Random excitation, Error analysis

Whenever random excitation is used in the determination of frequency response functions for a single degree of freedom system, the measurement accuracy depends on the frequency resolution of the measurement technique. If the ratio of measurement bandwidth to the 3 dB bandwidth of the resonance is too great, negative bias errors occur at resonance in estimates of power spectral levels and the transfer function parameters of amplitude and coherence. Numerical integration has been used to calculate the expected errors that result whenever Hanning or Kaiser-Bessel weighting is applied in a fast Fourier transform analysis and the errors that would be expected if an idealized rectangular frequency domain filter could be employed have also been similarly derived. The numerical data are presented and compared with appropriate experimental data.

81-2005

The Effect of Stationary Diffusers in the Measurement of Sound Absorption Coefficients in a Reverberation Room: An Experimental Study

G. Benedetto, E. Brosio, and R. Spagnolo

Istituto Elettrotecnico Nazionale Galileo Ferraris, Corso Massimo d'Azeglio 42, Turin, Italy, Appl. Acoust., 14 (1), pp 49-63 (Jan-Feb 1981) 19 figs, 21 refs

Key Words: Measurement techniques, Acoustic absorption, Reverberation chambers

Results of a series of measurements on different kinds of materials, performed in a reverberation room in both the presence and absence of diffusers are reported, in order to establish the effect of diffusing elements on the absorption coefficient values. In some cases variations greater than 40 per cent were observed.

81-2006

Determination of Sound-Power Levels for Industrial Purposes

K.J. Marsh

Engrg. Dept., The British Petroleum Co. Ltd., Britannic House, Moor Lane, London EC2Y 9BU, UK, Appl. Acoust., 14 (2), pp 113-127 (Mar-Apr 1981) 4 figs, 10 refs

Key Words: Equipment, Industrial facilities, Sound power levels, Noise measurement, Measurement techniques

New proposals for measuring the sound-power levels of industrial equipment are described. They are contained in the Noise Procedure Specification NWG-1, issued by the Oil Companies Materials Association and are intended for use in the petroleum and petrochemical industries, but it is suggested that they could have wider applications in other industries. The shortcomings of the ISO engineering methods for determining sound-power level are discussed and compared with the proposed test methods. Future needs for specific test methods in the oil industry are indicated.

81-2007

Real and Imaginary OSHA Noise Violations

T.H. Rockwell

Chesterland, Ohio, S/V, Sound Vib., 15 (3), pp 14-16 (Mar 1981) 8 figs, 1 table, 5 refs

Key Words: Noise measurement, Measurement techniques

Most users of sound measuring equipment assume that if they operate their instrumentation according to the manufacturer's directions, accurate and valid data will result. That assumption is faulty when the measurements are being made for OSHA compliance assessment in an environment that contains impulsive-type sounds. This article demonstrates the startling magnitude of the problem as it relates to "A"-weighted (slow) devices, and, in particular, to the personal noise dosimeter. Noise recordings from a press shop are ... d to show that these devices have the potential to not only over-estimate magnitudes of real problems, but they may also identify OSHA noise problems that don't really exist!

81-2008

Airblast Instrumentation and Measurement Techniques for Surface Mine Blasting

V.J. Stachura, D.E. Siskind, and A.J. Engler

Twin Cities Res. Ctr., Bureau of Mines, Twin Cities, MN, Bureau of Mines, Rept. of Investigations RI-8508, 53 pp (1981) 40 figs, 10 tables, 40 refs

Key Words: Blast loads, Mines (excavations), Measurement techniques, Measuring instruments

The Bureau of Mines has investigated techniques and instrumentation that measure accurately the airblast overpressures from surface mine blasting. Results include equivalencies between broadband research instrumentation and commercially available impulse precision sound level meters measuring: root-mean-square, peak, fast, slow, impulse, A and C weighting, C-weighted sound exposure level, and linear (flat) response. These values were obtained from field measurements and broadband FM tape recordings of production blasts at area and contour coal mines, limestone quarries, and iron mines. Frequency response was determined for 14 commercial systems.

81-2009

Measurements of Aerodynamic Damping in the MIT Transonic Rotor

E.F. Crawley
Gas Turbine and Plasma Dynamics Lab., Mass. Inst. of Tech., Cambridge, MA, Rept. No. NASA-CR-163988; GTL-157, 123 pp (Feb 1981)
N81-19122

Key Words: Measurement techniques, Aerodynamic damping, Aerodynamic loads, Rotors, Compressors

A method was developed and demonstrated for the direct measurement of aerodynamic forcing and aerodynamic damping of a transonic compressor. The method is based on the inverse solution of the structural dynamic equations of motion of the blade disk system in order to determine the forces acting on the system. The disturbing and damping forces acting on a given blade are determined if the equations of motion are expressed in individual blade coordinates. If the structural dynamic equations are transformed to multiblade coordinates, the damping can be measured for blade disk modes, and related to a reduced frequency and interblade phase angle. In order to measure the aerodynamic damping in this way, the free response to a known excitation is studied.

DYNAMIC TESTS

81-2010

Computer Aided Laboratory Simulation of Operational Loads (Rechnergesteuerte Betriebslastensimulation im Labor)

H.J. Mirow
Schwingungen von Maschine, Fundament und Baugrund, VDI Berichte 381, pp 81-87 (1980) 11 figs

Key Words: Test equipment and instrumentation, Computer-aided techniques

New instrumentation for laboratory simulation of several simultaneous operational excitations such as forces and motions up to above 100 Hz is described. Several applications are shown. The accuracy of the results is discussed.

81-2011

The Generation of Short Duration Acoustic Signals

J.C. Davies, J. McIntosh, and K.A. Mulholland
Dept. of Bldg Engrg., Univ. of Liverpool, Liverpool L69 3BX, UK, J. Sound Vib., 76 (1), pp 77-82 (May 8, 1981) 5 figs, 6 refs

Key Words: Acoustic tests, Pulse test method, Testing techniques

Recent developments in electronic and computer technologies have brought impulse techniques into prominence in a number of acoustic applications. A method whereby impulses of known shape and spectrum can be reliably reproduced is described. Pulses of shorter duration than the impulse response of the transducer have been reproduced by using this technique.

81-2012

A Nondestructive Evaluation Using Piezoelectric Polymer Transducers and Fourier Transform Vibrational Spectroscopy

D.H. Reneker, S. Edelman, A. Dereggi, and D.L. Vanderhart
Natl. Bureau of Standards, Washington, DC, Proc. Intl. Conf. Polymer Processing, MIT, Cambridge, MA, August 1977

Key Words: Nondestructive tests, Transducers, Fast Fourier transform

The normal mode vibrational spectrum of a particular object contains a wealth of information about the mechanical integrity of the object. The nondestructive evaluation of objects by observation of such vibrational spectra is facilitated by the combination of recently developed low mass, high compliance piezoelectric polymer transducers, a synchronized method for exciting the sample, and a small computer capable of making digital Fourier transforms. The sensitivity of this method to mass defects, modulus changes, and mechanical flaws in plastic objects is examined.

81-2013

Preliminary Vibration, Acoustic, and Shock Design and Test Criteria for Components on the Lightweight External Tank (LWT)

NASA Marshall Space Flight Ctr., Huntsville, AL, Rept. No. NASA-RP-1074; M-343, 322 pp (Feb 1981)

N81-19218

Key Words: Testing techniques, Design techniques, Spacecraft components, Propellant tanks

The Space Shuttle lightweight external tank is divided into zones and subzones. Zones are designated primarily to assist in determining the applicable specifications. A subzone is available for use when the location of the component is known but component design and weight are not well defined. When the location, weight, and mounting configuration of the component are known, specifications for appropriate subzone weight ranges are available. Along with the specifications are vibration, acoustic, shock, transportation, handling, and acceptance test requirements and procedures. A method of selecting applicable vibration, acoustic, and shock specifications is presented.

81-2014

Design and Construction of an Anechoic Chamber at the National Physical Laboratory of India

M. Pancholy, A.F. Chhapgar, and V. Mohanan

Natl. Physical Lab., New Delhi-110012, India, Appl. Acoust., 14 (2), pp 101-111 (Mar-Apr 1981) 4 figs, 13 refs

Key Words: Test facilities, Anechoic chambers

The new anechoic room of the National Physical Laboratory of India provides a free space of 3·5 x 3·5 x 3·5 m with a lower cut-off frequency of 70 Hz. Design details and performance characteristics of the chamber are discussed. Measures adopted to reduce the ambient noise level are also described.

81-2015

The USAF Armament Division Structural Dynamics Lab

W.O. Dreadin

Structural Dynamics Lab., Armament Div., Eglin Air Force Base, FL, J. Environ. Sci., 24 (2), pp 45-48 (Mar-Apr 1981) 10 figs

Key Words: Test facilities, Vibration tests

The Structural Dynamics Laboratory is a unique resource which can be scheduled by Department of Defense Agencies and defense contractors requiring armament testing. Testing is not limited to United States Defense Agency support but can be extended to all ally countries with armament testing as was recently demonstrated through a joint USAF/Canadian Forces ground vibration test. The Structural Dynamic Laboratory test capability is very versatile and can be extended to support many test requirements. Random input ground vibration testing has shown to be a very viable and useful test technique. The technique can provide more data .n less test time but also has limitations with which the test engineer must be familiar in order to provide accurate and meaningful results.

DIAGNOSTICS

81-2016

Recent Developments in Experimental Mechanics

H. Pih

The Univ. of Tennessee, Knoxville, TN, Acta Mech. Solida Sinica, Chinese Soc. Theor. and Appl. Mechanics, No. 2, pp 259-276 (1980) 179 refs

(In Chinese)

Key Words: Reviews, Fatigue life, Diagnostic techniques, Holographic techniques, Photoelastic analysis, Acoustic emission

Some recent developments and advancements in various areas of experimental mechanics in the USA, Western Europe and Japan are reviewed. In the area of commonly used techniques the new brittle coatings and the special strain gages for high temperature and cryogenic temperature applications are covered. In photomechanics the Moire method, two- and three-dimensional photoelasticity, dynamic photoelasticity, orthotropic photoelasticity, holography, speckle pattern interferometry and the method of caustics are reviewed. In experimental fracture mechanics methods of fatigue damage detection, application of photoelasticity in fracture studies, applications of holography in fracture mechanics, application of acoustic-emission method, and ultrasonic wave techniques are discussed. Finally, applications of micro-computers in experimental mechanics are treated.

81-2017
Identification and Correction of Machinery Vibration Problems
R.L. Eshleman
Vibration Inst., Clarendon Hills, IL 60514, S/V, Sound Vib., 15 (4), pp 12-14, 16-18 (Apr 1981) 14 figs, 3 tables, 11 refs

Key Words: Machinery vibration, Vibration measurement, Vibration analysis, Diagnostic techniques

Basic guidelines for the measurement and analysis of machinery vibration problems are presented. Various ways of evaluating the measured data for fault identification and basic methods for correcting or controlling vibration problems are discussed as well.

MONITORING

81-2018
Early Failure Detection in Cracked Flexural Vibrators – Crack Identification by Means of Spectral Analysis of Two Resonances (Schadensfruherkennung beim angerissenen Biegeschwinger – Rissidentifikation durch Spektralanalyse zweier Resonanzen)
W. Wedig and H. Brautigam
Schwingungen von Maschine, Fundament und Baugrund, VDI-Berichte 381, pp 45-52 (1980) 8 figs, 11 refs
(In German)

Key Words: Failure detection, Stochastic processes, Crack propagation

A method for the identification of transverse cracks in an elastic element of a flexural vibrator is presented, which from the stochastic response of the cracked vibrator, can determine the stiffness of the undamaged system and its actual stiffness which is reduced by the presence of the crack. This technique allows an early fault detection monitoring of crack propagation. The technique is simple for slightly damped systems. It can be performed without knowledge of natural frequencies and damping.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see No. 1984)

81-2019
Theory and Calculation Methods of Vibrating Structures
R. Valid
European Space Agency, Paris, France, Rept. No. ESA-TT-663, 94 pp (Dec 1980) (English transl. of "La Theorie et les Methodes de Calcul des Struct. en Vibration," Rept. No. ONERA-P-1980-1, 1980)
N81-19501

Key Words: Finite element technique, Displacement analysis, Vibration analysis

The finite element method is reviewed through use of the displacement method. Some details of the most common elements are given. The theory of linear vibrations is presented in the discretized case. Its properties, particularly variational ones, are reviewed in both the discrete and continuous cases. The main methods of dynamic condensation are described and standard formulas for response to specified excitations, whether transient, harmonic, periodic or random are given. Calculation methods for structures with geometric nonlinearities are presented in variational form. Calculation algorithms for arbitrary excitations are reviewed. The study of the stability of dynamic systems is introduced.

81-2020
Topological Matrices in the Equations of Discrete Vibrating Systems (Topologische Matrizen in den Gleichungen diskreter, ebener, dehnsteifer Schwinger)
D. Schade
ZAMM, 60 (9), pp 393-408 (Sept 1980) 24 refs
(In German)

Key words: Vibrating structures, Influence coefficient method, Matrix methods

When formulating equations of a vibrating system automatically in four different influence coefficients the topological net must be described. Equations with force influence coefficients (stiffness coefficients) and with strain influence coeffi-

cients use incidence matrices; displacement influence coefficients (flexibility coefficients) contain tree and mesh matrices. Equations with influence coefficients for internal forces appear in the form of sums and can be explained with tree and mesh matrices only for a special system.

81-2021

Vibrations Caused by Simultaneous Random Forced and Parametric Excitation (Schwingungen unter gleichzeitiger zufälliger Zwangs- und Parameteranregung)

G. Schmidt

Zentralinstitut f. Math. u. Mech., Akad. d. Wissenschaften der DDR, 1080 Berlin, Mohrenstr. 39, East Germany, ZAMM, 60 (9), pp 409-419 (Sept 1980) 9 figs, 12 refs

(In German)

Key Words: Random excitation, Parametric excitation

The vibrations of a one degree of freedom system with combined white noise random forced and parametric excitation and restoring, inertia and damping nonlinearities are investigated. By means of the thoery of Ito equations and an iterative method of Stratonovich generalizing the method of stochastic averaging, stationary solutions of the Fokker-Planck-Kolmogorov equation for the probability density of the amplitude are found which lead to results on different moments and the probability of exceeding a fixed amplitude level.

81-2022

On the Vibration of Linear Damped Systems

H.-c. Hu

Acta Mech. Solida Sinica, Chinese Soc. Theor. and Appl. Mechanics, No. 1, pp 30-37 (1980) 6 refs

(In Chinese)

Key Words: Damped structures, Linear systems, Eigenvalue problems, Vibration response

The vibration of linear damped systems with multiple degrees of freedom is discussed. The response is expanded in terms of the system eigenvectors by Laplace transform and partial fraction expansion. The effect of restricting the degrees of freedom on the eigenvalues is discussed. A complex amplification factor is defined in the case of resonance.

81-2023

The Transient Response Characteristics and Computational Model of Unstable Propagation of Cracks

Z.-q. Tang and Y.-p. Shen

Sian Chiao-Tung Univ., Acta Mech. Solida Sinica, Chinese Soc. Theor. and Appl. Mechanics, No. 1, pp 15-29 (1980) 10 figs, 2 tables, 33 refs

(In Chinese)

Key Words: Crack propagation, Boundary value problems, Transient response, Damped structures, Nonlinear systems

The dynamic properties of the unstable (fast) propagation of cracks, especially the rule of the variation of propagating velocity, are discussed. The case considered is one where the extension of cracks is not very long (as in the case of rapid crack propagation under impulsive load). The main idea of this paper is that the rapid propagation of cracks may be treated as a vibration problem and is associated with the basic conceptions of fracture mechanics (such as criterion of fracture, etc.) by the principle of energy equivalence.

81-2024

Dynamic Stress Concentration Studies by Boundary Integrals and Laplace Transform

G.D. Manolis and D.E. Beskos

Dept. of Civil & Mineral Engrg., Univ. of Minnesota, Minneapolis, MN, Intl. J. Numer. Methods Engrg., 17 (4), pp 573-599 (Apr 1981) 21 figs, 42 refs

Key Words: Hole-containing media, Dynamic stress concentration, Laplace transformation

The dynamic stress field and its concentrations around holes of arbitrary shape in infinitely extended bodies under plane stress or plane strain conditions are numerically determined. The material may be linear elastic or viscoelastic, while the dynamic load consists of plane compressional waves of harmonic or general transient nature. The method consists of applying the Laplace transform with respect to time to the governing equations of motion and formulating and solving the problem numerically in the transformed domain by the boundary integral equation method. The stress field can then be obtained by a numerical inversion of the transformed solution. The correspondence principle is invoked for the case of viscoelastic material behavior.

81-2025

Experiments on the Solution of the Helmholtz Equation Using the Finite Element Method and a Vari-

ational Approach in the Case of Domains of Complicated Boundary Shape

P.A.A. Laura, G.S. Sarmiento, R.O. Grossi, and G.M. Ficcadenti

Inst. of Applied Mech., 8111 Base Naval Puerto Belgrano, Argentina, Appl. Acoust., 14 (1), pp 27-32 (Jan-Feb 1981) 2 figs, 3 tables, 3 refs

Key Words: Membranes (structural members), Vibrating structures, Finite element technique, Conformal mapping, Variational methods, Eigenvalue problems, Boundary value problems

Domains of exotic boundary shape are of interest in several technological applications – acoustic and electromagnetic waveguides, solid propellant rocket cross-sections, printed circuit boards, etc. Experiments performed to determine the eigenvalues of a vibrating, ideal membrane are described. It is shown that the finite element method yields results which are in very good agreement with values determined by means of an analytical approach in the case of a membrane of a cardioidal shape.

81-2026

Direct Fourier Synthesis of Waves in Layered Media and the Method of Stationary Phase

S.M. Candel and C. Crance

Office National d'Etudes et de Recherches Aérospatiales (ONERA), 92320 Châtillon, France, J. Sound Vib., 74 (4), pp 477-498 (Feb 22, 1981) 10 figs, 16 refs

Key Words: Layered materials, Wave propagation, Direct Fourier Synthesis

A method of Direct Fourier Synthesis (DFS) for the calculation of wavefields in layered media is described. This technique may be used to obtain numerical solutions of many problems which have been previously treated by approximation methods. The DFS is here used to analyze radiation of a line source in the presence of a plane interface separating two half-spaces of different sound speeds. Approximate solutions of this problem obtained by a classical application of the method of stationary phase are compared with DFS results and it is found that their qualitative behavior and precision is not satisfactory. However it is shown that an initial change of co-ordinate system origin allows a notable improvement of results obtained by the method of stationary phase.

81-2027

An Energy Test for the Stability of Rheolinear Vibrations

J.G. Papastavridis

School of Engrg. Sci. and Mechanics, Georgia Inst. of Tech., Atlanta, GA 30332, J. Sound Vib., 74 (4), pp 499-506 (Feb 22, 1981) 20 refs

Key Words: Stability, Parametric vibration, Hill equation

An asymptotic expansion of a special form of d'Alembert's variational equation is combined with the "no resonance" vibration condition to calculate, approximately, the stability boundaries of the Hill-Mathieu equation. The interpretation of the resulting energy expressions leads to the formulation of a new kinetic stability criterion. Its degree of equivalence to other energy tests for non-conservative systems is established. Possible extensions of the methodology are mentioned.

81-2028

Solution of Radiation Problems by Collocation of Integral Formulations in Terms of Single and Double Layer Potentials

M.N. Sayhi, Y. Ousset, and G. Verchery

Centre Technique des Industries Mecaniques/CETIM, Senlis, France, J. Sound Vib., 74 (2), pp 187-204 (Jan 22, 1981) 16 figs, 15 refs

Key Words: Sound waves, Elastic waves, Collocation method

The purpose of this paper is the solution of the exterior steady state acoustic radiation problem for an arbitrary surface of which the normal velocity is specified, by using integral formulations. To obtain integral formulations, both a direct method, based on the surface Helmholtz integral equation, and an indirect method, based on single and double layer potentials, have been used. Filippi's method, with a hybrid potential, ensures uniqueness for any wavenumber. Three different surface elements have been used as a basis for obtaining approximate solutions by collocation of the integral equations. A comparison of the rates of convergence for the three surface elements is presented, based on a suitably defined overall error.

81-2029

A Periodic Problem in Viscoelasticity with Variable Coefficients

M. Raous

Laboratoire de Mécanique et d'Acoustique, C.N.R.S.-31, Chemin Joseph Aiguier, BP 71, 13277 Marseille Cedex 9, France, Intl. J. Engrg. Sci., 19 (8), pp 1145-1168 (1981) 15 figs, 2 tables, 26 refs

Key Words: Viscoelastic media, Variable material properties, Thermal excitation, Periodic excitation, Crack propagation, Aircraft engines, Turbine blades

A numerical method is proposed for solving a periodic problem for a material subjected to dynamic and thermal loading. Because of the considerable variations involved, a law of viscoelasticity of the fluid type with variable coefficients is adopted: secular terms of displacement and strain are brought into evidence. A theoretical asymptotic stability result of the related Cauchy problem makes it possible to measure a priori the rate of convergence of this solution towards the solution the periodic problem. The behavior predicted for the solutions is observed in the examples presented. A finite element method is used in combination with a Runge-Kutta method.

81-2030

On the Moments of Time to First Passage of the Linear Oscillator

L.A. Bergman and J.C. Heinrich

Dept. of Theoretical and Appl. Mechanics, Univ. of Illinois, Urbana, IL, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (3), pp 197-204 (May-June 1981) 8 figs, 1 table, 19 refs

Key Words: Random excitation, Failure analysis

The moments of time to first passage of the response process of the linear oscillator excited by a stationary wide-band process are obtained numerically for the symmetric two-sided barrier problem. A recursive set of partial differential equations governing the moments is solved using a Petrov-Galerkin finite element method. Stable, accurate solutions for the first few moments are calculated over a wide range of oscillator damping.

MODELING TECHNIQUES

81-2031

Generalized Effective Stiffness Theory for Nonelastic Laminated Composites

J. Aboudi

Dept. of Engrg. Sciences and Appl. Mathematics, Northwestern Univ., Evanston, IL 60201, Intl. J. Engrg. Sci., 19 (9), pp 1269-1281 (1981) 3 figs, 16 refs

Key Words: Mathematical models, Stiffness methods, Composite structures, Layered materials

Effective stiffness theory of the Nth order is derived for the modeling of the 3-dimensional dynamic motion of a laminated medium made of elastic-viscoplastic work-hardening constituents. The resulting theory represents the composite as a higher order homogeneous continuum with microstructure, whose motion is governed by higher order displacements and stresses. The derivation is systematic and can be applied to other types of nonelastic laminated media to the desired degree of accuracy.

81-2032

A Newer Class of Precise Oscillator Models

B.Z. Kaplan

Dept. of Electrical Engrg., Ben-Gurion Univ. of the Negev, Beer-Sheva, Israel, J. Franklin Inst., 311 (5), pp 299-309 (May 1981) 2 figs, 11 refs

Key Words: Oscillators, Mathematical models

A method has been presented in recent papers for deriving precisely stabilized waveform generators by relating them to second order conservative oscillators. The present paper demonstrates a method for modifying the previous models and in doing so a novel class of applicable oscillator models is established. Conditions that enable the models to sustain oscillations in steady state are described. A precise method for dynamically stabilizing the oscillator's waveforms is developed, and practical uses are suggested.

NUMERICAL METHODS

(See No. 2004)

STATISTICAL METHODS

81-2033

Transient Response of Non-Linear Systems to Random Excitation

J.B. Roberts

School of Engrg. and Appl. Sci., Univ. of Sussex, Falmer, Brighton BN1 9QT, UK, J. Sound Vib., 74 (1), pp 11-29 (Jan 8, 1981) 7 figs, 38 refs

Key Words: Nonlinear systems, Random excitation, Transient response, Method of stochastic averaging, Statistical analysis

An approximate method for computing the transient response of non-linear oscillators to suddenly applied, wide band random excitation is developed. The technique is derived initially for systems with non-linear damping, by using the method of stochastic averaging, and then generalized to deal with oscillators with arbitrary non-linear restoring forces. Predictions from the theory are compared with corresponding digital simulation estimates in a number of specific cases.

PARAMETER IDENTIFICATION

(Also see Nos. 1806, 1867)

81-2034

Simplification and Identification of Discrete Transfer Function via Step-Response Matching

C.G. Chung, K.W. Han, and H.H. Yeh
Dept. of Computer Sci., Chiao Tung Univ., Hsinchu, Taiwan, Rep. of China, J. Franklin Inst., 311 (4), pp 231-241 (1981) 6 figs, 13 refs

Key Words: System identification techniques, Step response

A computer-aided method for simplification and identification of linear discrete systems via step-response matching is presented. Golub's algorithm for solving least-squares problem is used to find the optimum coefficients of the reduced model. The advantages of this method are for model reduction, both the time response and frequency response within the bandwidth region of the reduced model are very close to those of the original system; and for system identification, the identified model is very close to the original system. In the illustrative examples considered in this paper the results of the proposed method appear to be better than those of other methods in the current literature.

OPTIMIZATION TECHNIQUES

(See No. 1874)

COMPUTER PROGRAMS

(Also see No. 1891)

81-2035

Three-Dimensional Oscillatory Piecewise Continuous-Kernel Function Method - Part II: Geometrically Continuous Wings

I. Lottati and E. Nissim
Technion-Israel Inst. of Tech., Haifa, Israel, J. Aircraft, 18 (5), pp 352-355 (May 1981) 1 fig, 8 tables, 18 refs

Key Words: Computer programs, Aircraft wings

The rapid convergence and high-accuracy characteristics of the three-dimensional piecewise continuous-kernel function method are tested in the present work. The large number of numerical examples are aimed at showing the computational efficiency of the method. Three-dimensional wings with no geometrical discontinuities along their spans (discontinuities are permitted at the wing root only) are treated. Problems associated with geometrical discontinuities (such as break points, control surfaces, etc.) are presented in Part III of this work.

81-2036

Transient Dynamic Analysis of High-Speed Lightly Loaded Cylindrical Roller Bearings. 2: Computer Program and Results (Final Report)

T.F. Conry and P.R. Goglia
Univ. of Illinois, Urbana, IL, Rept. No. NASA-CR-3335, 62 pp (Jan 1981)
N81-16472

Key Words: Computer programs, Bearings, Roller bearings

The governing differential equations of motion for a high speed cylindrical roller bearing are programmed for numerical solution and plotted output. This computer program has the capability of performing a two dimensional or three dimensional simulation. Two numerical solutions of the governing differential equations were obtained to simulate the motion of a roller bearing – one for the two dimensional equations of motion and one for the three dimensional equations of motion. Computer generated plots were obtained and present such data as roller/cage interaction forces, roller/race traction forces, roller/race relative slip velocities and cage angular speed over a nondimensional time equivalent to 1.2 revolutions of the inner race. Roller axial displacement, roller skew angle, and skew moment are also plotted for the three dimensional solution. The trajectory of the cage center is plotted for both the two dimensional and three dimensional solutions.

81-2037

Nastran Level 16 Theoretical Manual Updates for Aeroelastic Analysis of Bladed Discs

V. Elchuri and G.C.C. Smith

Textron Bell Aerospace Co., Buffalo, NY, Rept. No. NASA-CR-159823; D2536-941002, 24 pp (Mar 1980)
N81-19480

Key Words: Computer programs, NASTRAN (computer programs), Disks, Blades, Flutter

A computer program for aeroelastic analyses, modes and flutter based on state of the art compressor and structural technologies applied to bladed shrouded disc was developed and made operational in NASTRAN Level 16. Theoretical manual updates are included.

81-2038
NASTRAN Level 16 User's Manual Updates for Aeroelastic Analysis of Bladed Discs
V. Elchuri and A.M. Gallo
Textron Bell Aerospace Co., Buffalo, NY, Rept. No. NASA-CR-159824; D2536-941003, 167 pp (Mar 1980)
N81-19481

Key Words: Computer programs, NASTRAN (computer programs), Disks, Blades, Flutter

The NASTRAN aeroelastic and flutter capability was extended to solve a class of problems associated with axial flow turbomachines. The capabilities of the program are briefly discussed. The aerodynamic data pertaining to the bladed disc sector, the associated aerodynamic modeling, the steady aerothermoelastic design/analysis formulations, and the modal, flutter, and subcritical roots analyses are described. Sample problems and their solutions are included.

81-2039
NASTRAN Level 16 Programmer's Manual Updates for Aeroelastic Analysis of Bladed Discs
A.M. Gallo and B. Dale
Textron Bell Aerospace Co., Buffalo, NY, Rept. No. NASA-CR-159825; D2536-941004, 88 pp (Mar 1980)
N81-19482

Key Words: Computer programs, NASTRAN (computer programs), Disks, Blades, Flutter

The programming routines for the NASTRAN Level 16 program are presented. Particular emphasis is placed on its application to aeroelastic analyses, mode development, and flutter analysis for turbomachine blades.

81-2040
NASTRAN Level 16 Demonstration Manual Updates for Aeroelastic Analysis of Bladed Discs
V. Elchuri and A.M. Gallo
Textron Bell Aerospace Co., Buffalo, NY, Rept. No. NASA-CR-159828; D2536-941005, 15 pp (Mar 1980)
N81-19483

Key Words: NASTRAN (computer programs), Disks (shapes), Blades, Flutter

A computer program based on state of the art compressor and structural technologies applied to bladed shrouded discs was developed and made operational in NASTRAN Level 16. The problems encompassed include aeroelastic analyses, modes, and flutter. The demonstration manual updates are described.

81-2041
Aeroelastic and Dynamic Finite Element Analyses of a Bladed Shrouded Disk
G.C.C. Smith and V. Elchuri
Textron Bell Aerospace Co., Buffalo, NY, Rept. No. NASA-CR-159728; D2536-941001, 152 pp (Mar 1980)
N81-19479

Key Words: Computer programs, Disks, Blades, Shrouds, Flutter

The delivery and demonstration of a computer program for the analysis of aeroelastic and dynamic properties is reported. Approaches to flutter and forced vibration of mistuned discs, and transient aerothermoelasticity are described.

81-2042
Piping Flexibility Analysis with a Programmable Calculator
A. D'Ambra
Heating/Piping/Air Cond., 53 (5), pp 68-76 (May 1981) 3 tables

Key Words: Computer programs, Piping systems, Flexibility coefficients

A program to facilitate thermal flexibility analysis of two-anchor, single plane piping utilizing a TI 59 programmable calculator with printer is presented. It has allowances for the inclusion of the effects of three-dimensional translational and rotational motion at each anchor. The program is intended to be most appropriate for the situation where the end motion may be relatively complicated, a quick reasonably accurate answer is required, and computers are not available. The program also permits relatively simple desk top investigation of different cases to give the designer a better feel for piping flexibility behavior under various thermal or end motion conditions.

81-2043

Soil-Structure Interaction Methods. Volume III. SIM Code

C.A. Miller and C.J. Costantino

Brookhaven Natl. Lab., Upton, NY, Rept. No. BNL-NUREG-51263-Vol. 3, 99 pp (Jan 1981)
NUREG/CR-1717-V-3

Key Words: Computer programs, Interaction: soil-structures, Underground structures

SIM Code treats the forced response of a partially buried structure to a specified disturbance traversing the location of the structure. A solution to this problem requires consideration of the structural model; soil/structure interaction; the free field disturbance; and numerical aspects of the solution. Each of these is discussed.

81-2044

Inelastic Material Models in Earthquake Response

C.O. Hays, Jr.

Civil Engrg., Univ. of Florida, Gainesville, FL 32611, ASCE J. Struc. Div., 107 (1), pp 13-28 (Jan 1981)
14 figs, 19 refs

Key Words: Computer programs, Frames, Earthquake response

A computer program for the static and dynamic analysis of plane frames subjected to large inelastic deformations is reviewed. Nonlinear material, soil structure, and geometric effects are simultaneously considered. Problems are solved showing the influence of the stress-strain model on the static and dynamic response of frames subjected to large static load reversals and earthquake motions. Results indicate that while more accurate models are available for structural steel, the relatively simple Masing model is able to simulate the inelastic force-deformation response of frames quite well over a large range of inelastic deformations; even plastic-hinge models may predict accurate frame response.

81-2045

Resonances in Acoustic Bottom Reflection and Their Relation to the Ocean Bottom Properties

W.R. Hoover, A. Nagl, and H. Ueberall

Dept. of Physics, Catholic Univ. of America, Washington, DC, Interim Technical Rept., 1 Feb 1980 - 31 Jan 1981, 24 pp (Jan 1981)
AD-A094 147

Key Words: Computer programs, Underwater sound, Acoustic reflection

We have initiated a program to study the resonances in the acoustic reflection coefficient of a layered ocean bottom, patterned after the resonances of sound reflection from fluid or elastic layers. Computer programs have been written for obtaining the reflection coefficient from multi-layered fluid or elastic media, with constant or linearly depth-dependent sound velocities in each layer. Resonances are evident in the reflection coefficient both as functions of frequency and of angle of incidence, and are shown to depend on the properties of the layered ocean bottom. Results will be presented in the form of three-dimensional graphs.

GENERAL TOPICS

CRITERIA, STANDARDS, AND SPECIFICATIONS

81-2046

Community Noise in Twenty Kentucky Cities

A.B. Broderson, R.G. Edwards, W.P. Hauser, and W.S. Coakley

Watkins & Assoc. Inc., Engineers/Architects/Planners, 446 E. High St., Lexington, KY 40588, Noise Control Engrg., 16 (2), pp 52-63 (Mar-Apr 1981)
9 figs, 4 tables, 22 refs

Key Words: Regulations, Noise measurement, Urban noise, Human response

In preparation for state regulation of environmental noise, a year-long study of the noise environment in 20 Kentucky cities was conducted. A total of 500 hours of short-term statistical noise data was collected at 638 sites, representing several land and use classes. The mean, short-term, daytime L_{eq} was 59.1 dB with a standard deviation of 7.4 dB, sufficient to produce substantial annoyance and a small potential for hearing loss. Noise did not differ significantly between cities, land-use classes, or type of transportation, but did differ significantly from day to night (5.5 dB) and between land-use boundaries and centers (5.5 dB). The major intrusive noise was from transportation vehicles, particularly automobiles (41.4%).

AUTHOR INDEX

CALENDAR

SEPTEMBER 1981

14-17 International Off-Highway Meeting and Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

20-23 Design Engineering Technical Conference [ASME] Hartford, CT *(ASME Hqs.)*

28-30 Specialists Meeting on "Dynamic Environmental Qualification Techniques" [AGARD Structures and Materials Panel] Noordwijkerhout, The Netherlands *(Dr. James J. Olsen, Structures and Dynamics Division, Air Force Wright Aeronautical Laboratories/FIB, Wright Patterson Air Force Base, OH 45433)*

28-30 Stapp Car Crash Conference [SAE] San Francisco, CA *(SAE Hqs.)*

30-Oct 2 Intl. Congress on Recent Developments in Acoustic Intensity Measurement [CETIM] Senlis, France *(Dr. M. Bockhoff, Centre Technique des Industries Mecaniques, Boite Postale 67, F-60304, Senlis, France)*

OCTOBER 1981

4-7 Intl. Lubrication Conference [ASME-ASLE] New Orleans, LA *(ASME Hqs.)*

5-8 SAE Aerospace Congress and Exposition [SAE] Anaheim, CA *(Roy W. Mustain, Rockwell Space Systems Group, AB 97, 12214 S. Lakewood Blvd., Downey, CA 90241)*

11-15 Fall Meeting of the Society for Experimental Stress Analysis [SESA] Keystone, CO *(SESA, P.O. Box 277, Saugatuck Station, Westport, CT 06880)*

19-22 Intl. Optimum Structural Design Symp. [U.S. Office of Naval Research and Univ. of Arizona] Tucson, AZ *(Dr. Erdal Atrek, Dept. of Civil Engr., Bldg. No. 72, Univ. of Arizona, Tucson, AZ 85721)*

21-23 34th Mechanical Failures Prevention Group Symp. [National Bureau of Standards] Gaithersburg, MD *(J.E. Stern, Trident Engineering Associates, 1507 Amherst Rd., Hyattsville, MD 20783 - (301) 422-9506)*

26-30 ASCE Annual Convention & Exposition [ASCE] St. Louis, MO *(ASCE Hqs.)*

27-29 52nd Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, D.C.] New Orleans, Louisiana *(Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, D.C. 20375)*

NOVEMBER 1981

9-12 Truck Meeting & Exposition [SAE] Dearborn, MI *(SAE Hqs.)*

15-20 ASME Winter Annual Meeting [ASME] Washington, D.C. *(ASME Hqs.)*

16-19 Intl. Pacific Conference on Automotive Engineering [SAE] Honolulu, Hawaii *(SAE Hqs.)*

17-19 Technical Diagnostics Symposium [IMEKO Technical Committee on Technical Diagnostics] London, England *(Institute of Measurement and Control, 20 Peel Street, London W8 7PD, England)*

18-20 Fourth SAE Intl. Conference on Vehicle Structural Mechanics [SAE] Detroit, MI *(SAE Hqs.)*

30-Dec 4 Acoustical Society of America, Fall Meeting [ASA] Miami Beach, FL *(ASA Hqs.)*

DECEMBER 1981

1-3 10th Turbomachinery Symposium [Texas A&M University] Houston, TX *(Peter E. Jenkins, Director, Turbomachinery Laboratories, Dept. of Mechanical Engineering, Texas A&M University, College Station, TX 77843 - (713) 845-7417)*

1-3 Automotive Plastics Durability Conference and Exposition [SAE] Troy, MI *(SAE Hqs.)*

8-10 Western Design Engineering Show [ASME] Anaheim, CA *(ASME Hqs.)*

FEBRUARY 1982

22-26 SAE Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1982

29-Apr 1 Design Engineering Conference and Show [ASME] Chicago, Illinois *(ASME Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

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A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7, pp 97-106 (July 1975).
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